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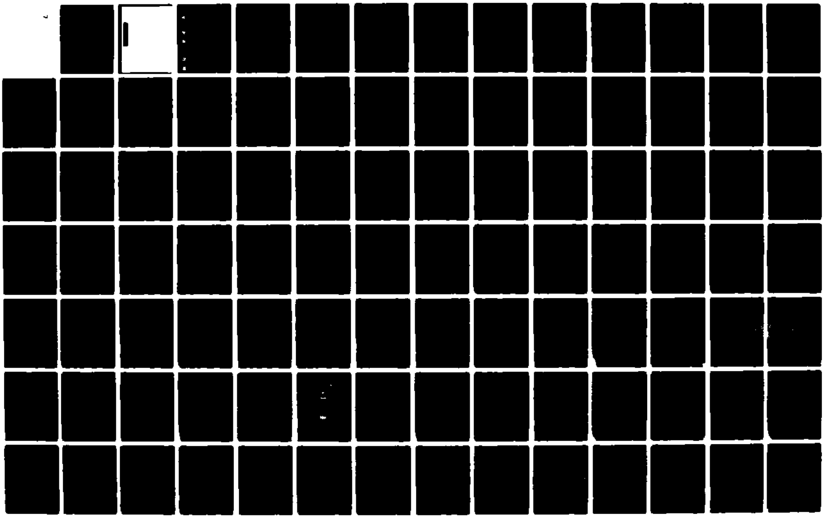

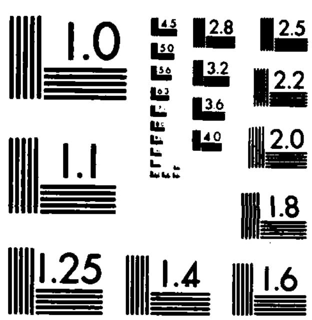

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The purpose of this report is to present a complete record of the geology and foundation conditions encountered during construction of dam. The report focuses primarily on the foundations of the outlet works, right abutment, and spillway area where the bulk of rock foundations are involved.

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OPERATION AND MAINTENANCE MANUAL
MILFORD DAM AND LAKE
REPUBLICAN RIVER, KANSAS
KANSAS RIVER BASIN

APPENDIX IV
CONSTRUCTION FOUNDATION REPORT

1977
(Revised October 1983)

DEPARTMENT OF THE ARMY
Kansas City District, Corps of Engineers
Kansas City, Missouri

OPERATION AND MAINTENANCE MANUAL
MILFORD DAM AND LAKE
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CHAPTER 1

INTRODUCTION

1-01. Location and Description. Milford Dam is located 4 miles northwest of Junction City, Kansas. It is situated on the Republican River 8.3 miles above it's confluence with the Smoky Hill River which becomes the Kansas River eastward of this point. The area is served by major U.S. Highways 70 and 77 and the Union Pacific Railroad. The project consists of an earth and rock embankment stretching 6,300 feet north-south across the valley, a concrete outlet works, and a chute type uncontrolled spillway. The height of the embankment is 147 feet above the streambed. The maximum width of the embankment is 1,050 feet. Located along the right abutment is a reinforced concrete outlet works consisting of an intake control tower, a cut and cover conduit, and a stilling basin. This structure is designed to handle discharge flows up to a maximum of 26,900 cubic feet per second. Discharge flows are controlled by two hydraulically operated gates in the control tower. The spillway is located about 3,000 feet south of the embankment utilizing two large topographic draws. It is an uncontrolled, emergency, chute type spillway with a concrete sill 1,250 feet long. Full pool reservoir level is at elevation 1176.2 m.s.l. with storage capacity of 757,746 acre feet. The reservoir level at conservation pool is at elevation 1144.4 m.s.l. making a reservoir of 16,189 acres.

1-02. Construction Authority. This project was authorized by Public Law 83-780 in 1954 by the 83rd Congress of the United States. It is part of the Missouri River basin flood control plan. The project was advertised for competitive bids in the spring of 1962. Western Contracting Corporation of Sioux City, Iowa was awarded the contract for a low bid of $13,965,840.00, and construction operations began in the fall of that year.

1-03. Purpose and Scope. The purpose of this report is to describe the construction operations, provide a record of the foundation conditions and to discuss problems encountered during construction. The report will also deal with the geological aspects of the project construction with emphasis on bedrock foundation conditions, materials utilization, and other items which have geologic relationship. The Resident Engineer was Mr. Richard Griffith and the project geologist was Mr. Steve D. Markwell.

CHAPTER 2

GEOLOGY AND PHYSIOGRAPHY

2-01. General. Milford Dam is located in the Osage Plains section of the Central Lowlands physiographic province in the middle of the Permian escarpment belt.

a. The topography of the area is in a stage of maturity to old age with broad U-shaped valleys separated by flat-topped highlands. These highlands have been appropriately named the "Flint Hills" due to the cherty limestones from which they have been carved. Rocks of Permian age crop out in the vicinity of Milford Dam. All bedrock materials encountered during construction are classified as belonging to the Chase group of the Wolfcampian series. This series has been referred to in older publications as the "Big Blue Series." It represents the oldest Permian sedimentary sequence in the state of Kansas. The Chase group, the upper bedrock division of the Wolfcampian series, consists of alternating argillaceous limestones and shales. A thickness of approximately 200 feet of bedrock strata were encountered during construction. The bedrock formations of this sequence are the Doyle shale, the Barneston limestone, the Matfield shale and the Wreford limestone. For the generalized geologic column see figure 2. A geologic map of the construction area is shown on figure 3.

b. Overburden materials in the area may be divided into three types: (1) residual soil mantle; (2) loess deposits; and (3) floodplain alluvium. Residual soils are thin, generally less than one foot thick. They are predominately organic clays and are black in color. These soils were stripped and placed in waste areas. The loess is found blanketing the higher elevations, generally above elevation 1200 m.s.l. The maximum thickness encountered is 30 feet in the vicinity of the spillway sill. It is generally classified as a lean clay, although isolated areas of silts and fat clays are also found. Loess deposits were utilized as impervious fill in the blanket and in the embankment. It is a heavy clay and is not particularly easy to work. It was generally placed in the blanket areas where moisture control was not required. Maximum thickness of the alluvium is 57 feet. The alluvial sands are generally fine grained in the upper 20 feet with coarser materials predominating below that depth at an approximate elevation of 1065 m.s.l. The more coarse materials are generally medium grained with some coarse grained sands. Gravel deposits are spotty and particles larger than 3/8-inch are absent. Clay layers in the alluvium appear to be continuous over long distances and range from 1 to 5 feet in thickness. In many instances, the clay layers are mixed with a layer of cobbles and boulders. Clays and silts are found in the terraces along the margins of the valleys. Much of this material is reworked loess transported from the higher elevations. These terrace areas produced the major portion of the impervious borrow materials utilized in the central core of the embankment.

c. Sand of the upper alluvium excavated from the downstream borrow area produced the major portion of the pervious material. A considerable portion of the random material was also obtained from this area.

2-02. Bedrock Structure. The project is located between two major structural features; the Nemaha arch to the east and the Salina basin to the west. A minor structural feature, the Abilene anticline, cuts through the upper end of the reservoir area. These features trend generally north-south; however, they are deeply buried and have little influence on the surface rocks. Regional dip is five to ten feet per mile to the northwest. Local minor undulations of a few feet commonly occur in the bedrock strata. With essentially flat lying bedrock excavation operations were relatively simple. Local geologic structure had little effect on the construction operations.

2-03. Bedrock Stratigraphy. Rock strata outcropping at the damsite, from youngest to the oldest, are described in the following paragraphs. Laboratory test data is shown in Table - 8.

a. Doyle Shale Formation. The Doyle Shale Formation represents the youngest bedrock strata in the vicinity of the dam. In the construction area, only the two lower members of this formation are present, Towanda limestone member and Holmesville shale member.

(1) Towanda Limestone Member. The Towanda limestone member is approximately 15 feet thick in the vicinity; however, it exists primarily in a cap rock condition and the thickness varies greatly. The upper 4 feet is generally a soft, friable limestone, light gray in color, clayey and thin bedded giving it a platy appearance. The full thickness of this zone is present only in areas of thick overburden. This zone is unconformable with the harder limestone zone below and in some areas it forms the greater portion of the member. Towanda limestone is easily ripped for use as a construction material. Underlying this soft upper zone is an interval of hard, gray limestone with an average thickness of 8 feet. This interval varies considerably in thickness. It is generally massive to thick bedded and contains numerous fractures. The material has an average density of 145 pounds per cubic foot and an absorption ranging from 3 to 4 percent. This zone, although discontinuous, produced the best limestone material excavated during construction with regard to hardness and durability. The lower zone of the Towanda limestone is a 3-foot thick interval of hard, medium-bedded limestone. A solution horizon is present in this interval varying from 0 to 2.7 feet thick. This horizon contains heavily weathered limestone and a soft, silty, clay.

(2) Holmesville Shale Member. The Holmesville member in this area consists of 18 feet of soft, varicolored clay shale. The upper 4 feet is yellowish brown and contains a network of hard calcareous material. The middle consists of a greenish shale with a distinct red horizon. Horizontal cleavage planes are well developed in this interval as well as vertical and high angle joints. The lower portion of this member is predominantly dark gray and soft. Two distinct limestone beds, 0.8 feet thick in this zone, form a continuous resistant horizon throughout the area. It is well exposed along the side slopes and floor of the spillway. Holmesville shale was used as shale and limestone fill.

b. Barneston Limestone Formation. The Barnestone formation is about 80 feet thick. It is made up of argillaceous limestone with a few thin calcareous shale beds. The formation is divided into three members: The Fort Riley limestone, Oketo shale, and the Florence limestone. It is well exposed along the walls of the Republican river valley.

(1) Fort Riley Limestone Member is divided into five zones:

(a) Zone "A" is a moderately hard, argillaceous, limestone, tan to brown in color and medium bedded. The ledge upon exposure and weathering breaks down into a platy structure and resembles a shale. The general thickness is 15 feet. This zone is solutioned which exhibits enlarged bedding planes, stained joints, and cavities. A few thin shale seams are present in this zone and are characteristically green, laminated, and soft. In many instances these shale seams have weathered to soft clay, particularly in the lower portion of the zone. This zone is capable of transporting groundwater and considerable attention was given to it during grouting. The downstream key of the spillway sill cuts off this entire zone. The zone is above groundwater level and about 24 feet above conservation pool level.

(b) Zone "B" of the Fort Riley is the upper of two resistant beds forming one of the three "rimrock" ledges which outcrop in the area. It is generally 5 feet thick and is "pock marked" by numerous vugs. Generally, it is characterized by two thick beds separted by an open bedding plane. This horizon is capable of carrying seepage but is situated above the water table and supports no permanent springs.

(c) Zone "C" is 10 feet thick and its dark gray color makes it an excellent marker bed for correlation. It is very argillaceous, bordering on being a shale. Occasional vugs similar to the zone above are present, many of these exhibiting secondary calcite mineralization.

(d) Zone "D" is 9.5 feet thick, moderately hard, tan, pitted limestone. It is massive to thick massive to thick bedded with distinct bedding plane located 5.5 feet above the base. The density of this zone averages 140 pounds per cubic foot with an absorption ranging from 8 to 12 percent. Upon exposure, the lower 5.5 feet case hardens and the color changes to white. This results in a hard white limestone at the outcrop, gradually grading back to the original softer limestone as the cover increases. This bed is locally called the "white ledge" or "rimrock" ledge and has been quarried for cut stone building material in the state of Kansas for the last 100 years. The ledge was quarried at this project for use as riprap. The bedding plane at the base of zone "D" is also a seepage zone and has been enlarged by solutioning. It is the major spring zone of the area producing numerous small springs in the larger draws in the vicinity of the left abutment.

(e) Zone "E" marks the base of the Fort Riley member and consists of a shaly limestone with a thickness of 2 feet. It is hard and tan and contains numerous fossil fragments. Toward the outcrop the material is thin bedded and platy.

(2) Oketa Shale Member. Oketo is a dark gray, calcareous shale about 6 feet thick and is an excellent marker bed.

(3) Florence Limestone Member. The Florence limestone consists of 34 feet of argillaceous, cherty, limestone with thin calcareous shale layers in the upper part. It is tan in color with dark blue to occasionally purple chert nodules. Like the Fort Riley, the Florence has been subdivided into zones.

(a) Zone "A" is a medium bedded limestone with several calcareous shale beds. An abundance of chert is present as irregular masses in continuous horizons. The shale layers are practically unrecognizable in the unweathered state. However, like the "E" zone of the Fort Riley member, the layers become distinct when exposed to weathering.

(b) Zone "B" of this member is a massive 5-foot thick ledge which is free of chert. It is somewhat similar to the "D" zone of the Fort Riley in that it is pitted and exhibits some degree of case hardening when exposed. This ledge forms the lower rimrock of the area and like the other rimrock ledges, has an associated bedding plane at its base that is considered a seepage horizon.

(c) Zone "C" is a 10-foot zone of argillaceous limestone containing the highest percent of chert in the area. It is tan and thick to massive bedded; however, it spalls rapidly when exposed.

(d) Zone "D" is a 4-foot transitional zone between the cherty Florence limestone and the underlying shale. It consists of a soft, very argillaceous, dark gray limestone which breaks down readily upon exposure.

c. Matfield Shale Formation. Consists of two thick shale members; the Blue Springs and the Wymore, separated by the Kinney limestone member. The total thickness of 60 feet was exposed in the outlet works excavation.

(1) Blue Springs Shale Member. The Blue Springs shale is the upper member of the Matfield shale formation. The upper portion consists of alternating red and green shales. The shale is clayey and soft with the exception of a hard limestone bed, 1-foot thick, located approximately 4 feet above the base. This zone marks the upper extent of gypsum mineralization present in the form of elongated nodules and irregular masses, red in color, associated with the jointing. The lower Blue Springs consists of 12 feet of dark gray, calcareous shale moderately soft with thin, discontinuous satin spar gypsum usually associated with the numerous horizontal cleavage planes that are well developed toward the base.

(2) Kinney Limestone Member. The Kinney limestone is a hard, gray, and generally massive ledge 6.5 feet thick. Isolated gypsum masses up to 4 inches in diameter are scattered at random in this ledge. This limestone was observed in the stilling basin section of the outlet works excavation.

(3) Wymore Shale Member. The upper part (Zone A) consists of a hard calcareous weather resistant shale containing horizontal cleavage planes. The lower part (zone B) is a soft clay shale predominately green in color with a red layer and a thin purple layer. The lower portion becomes increasingly more calcareous and harder toward the base. A gypsum seam was observed, in the form of satin spar, in the lower portion. This seam is undulated slightly and showed minute displacement in one area; however, there was no indication of displacement of the adjacent materials. This seam was tight and no evidence of solutioning was observed. At the contact with the upper part, the shale had been softened by ground water and several small springs emitted from this horizon in the downstream and riverward slopes of the stilling basin excavation.

d. Wreford Limestone Formation. The upper limestone member, the Schroyer, was encountered in the lower portion of the stilling basin excavation. The two lower members of this formation; the Havensville shale and the Three Mile limestone are below required excavation. The Schroyer limestone is approximately 10 feet thick. The upper 3 feet consists of a single massive limestone ledge; hard and light gray to white in color. The remainder of the Schroyer consists of a moderately hard, dark gray, argillaceous limestone with two dark gray chert horizons in irregular masses similar to those found in the Florence limestone. Numerous gypsum nodules up to 4 inches in diameter are scattered throughout. The content of gypsum in the Schroyer is very high, far exceeding any other interval encountered. There is no particular pattern to these masses. However, a high concentration of gypsum was associated with and incorporated within the chert. With the exception of a thin, cherty, gray limestone (0.8 feet thick) the lower Schroyer becomes more argillaceous toward the base with an overall decrease in hardness. Thin satin spar gypsum seams were noted in the lower part beneath the thin limestone.

CHAPTER 3

FOUNDATION CONDITIONS AND TREATMENT

3-01. Grouting General.

a. Preliminary investigations prior to construction indicated some seepage through the abutment bedrock might be expected. During the drilling of initial borings, high or total losses of drilling fluid occurred. For a layout of the entire drilling program see figure 18 and plates No's. 13 and 14. Through a study of the bedrock cores and pressure test data, it was possible to establish the potential seepage pattern. Six core borings were pressure tested, (see table 9 Pressure Test Data.) Of these borings, 2 were drilled on the right abutment, 2 on the left abutment, and 2 in the spillway area. Examination of the drill core and comparison of pressure test data indicated a foundation leakage potential in the Fort Riley limestone more severe than those usually encountered in the Kansas City District. Seepage through open joints was found to be negligible, with the exception of areas immediately adjacent to outcrop faces or just below the top of bedrock. The major seepage was found in openings along bedding planes. Three of the four major seepage zones were directly associated with the prominent rimrock ledges previously described; the B and D zones of the Fort Riley and the B zone of the Florence. These zones are in essence enlarged bedding planes. The solution zone of the "A", upper zone of the Fort Riley, is not associated with an outcrop ledge. With a pattern established, a reasonable prediction could be made as to seepage potential of the various areas, greatly simplifying the remainder of the testing program. A test grouting program was performed by Government personnel prior to construction in 1962. A full report on the test grouting is given in Supplement A, (located in the back part of this manual). A summary of Test Grouting is shown in Table - 10. The test sections extended from station 82+20 to station 88+64 on the right abutment and from station 143+00 to station 151+00 on the left abutment. These sections were completed as a single line curtain penetrating to a depth of 125 feet to a general elevation of 1085 m.s.l. The grout curtain extended from the Towanda limestone member downward to just into the Blue Springs shale member. The grout holes were 3 inches in diameter and were drilled vertically to the desired depth. Pressure testing and the stop grouting were accomplished by setting packers in the lowest portion of the hole and resetting the packer at intervals progressively upward. Pressures were generally 1.5 - 2.0 pounds per foot of vertical depth including the column pressure. The water cement ratio of the grout mixes varied from 0.6:1 to 4:1. Primary holes were drilled on 80 foot centers. As drilling operations progressed, the spacing was reduced to 40 feet. The grout takes were not excessively high. The predicted horizontal zones showed openings to some degree.

b. Secondary holes split-spaced the primaries, reducing the hole spacing along the curtain to 20 feet. Grout placement in the secondaries, in general, showed a marked reduction. A tertiary hole series was then drilled reducing the grout hole spacing to 10 feet. The grout curtain test sections were essentially completed at this 10-foot center to center spacing although some quaternary holes were drilled along the line.

c. Angle holes. As an additional check, angle holes were drilled along the line. These were either tight or experienced negligible grout takes. To check the feasibility of the stage grouting method some holes were grouted in this manner, and it was found to be successful. For location of these sections see figure 19.

3-02. Right Abutment Grout Curtain. Initial contract grouting operations were started in February 1963. The excavation of the right abutment cutoff had been virtually completed with the foundation excavation for the conduit approximately 3 feet above grade and grouting was performed from top of bedrock. The right abutment curtain extended along the dam centerline from station 90+80, a point 80 feet riverward of the conduit centerline, across the foundation and up the cutoff slope to the top of the abutment at station 88+25, overlapping the test section. All grouting was completed by the stage method, i.e., the hole was drilled at an angle of 30 degrees (from vertical) to either a specified depth or to a zone of open conditions. The hole was then pressure tested and grouted. The hole was then deepened and the process repeated. The curtain was divided into two zones in the slope portion of the line. All drilling was accomplished with a CP 65 portable drill either mounted on a platform wagon or attached to a grouted nipple. (See photos 42 thru 44). The right abutment curtain was divided into three sections for the grouting operations. This was done on the basis of access to the work areas. For location of the grout curtain and its sections see figures 19 and 20. The grout plant was standard grouting layout equipped with a 20 cubic feet mixing vat, water meter and slush pump with a rated capacity of 50 g.p.m. at 150 pounds of pressure per square inch (see photo 47). All couplings and fittings were 1.5 inch ID. The grout tree of the header was equipped with bypass, bleeder valve and pressure gage. Gages used in most cases were 30 pound maximum gages. Pressure testing was accomplished through the header with a water meter inserted between the hole and the header in the line (see photos 42 thru 44). The grout curtain sections were completed satisfactorily and a relatively tight curtain was achieved. A summary of contract grouting is shown on Table - 11.

a. Section I.

(1) Primary holes. Section 1 included that portion of the curtain beneath the conduit foundation from its riverward extent to the toe of the cutoff slope. The primary holes were drilled on 10 foot centers and all holes were drilled to the bottom of the curtain with no indication of open conditions. These holes penetrated the lower Blue Springs shale, the Kinney limestone and the upper Wymore shale. Drilling was done with an E size bit (1-1/2-inch diameter). If anticipation of a tight zone is possible the zone of section I appeared to be that. The first open joint had been found in the foundation of the approach slab some 400 feet upstream and there was no indication that this condition was more than a very localized condition. As a check on these initial holes, a washing operation of air and water was used (see photos 42 thru 44). The wash water return from some of the holes was a dark gray color similar to the lower Blue Springs shale. This was attributed to soft shale cuttings within the holes; however, it was these holes in

particular which had significant grout "takes." Later information obtained on clay filled openings in this shale during foundation preparations lead to the assumption that washing had cleaned out the clay filling of the joints and allowed higher grout takes.

(2) Pressure test. Grouted nipples 2.0 feet in length were set and the process of grouting and pressure testing started moving riverward along this section. Initial pressures on the first holes were maintained at 1.0 psi per lineal foot of hole including the column pressure. However, as operations progressed riverward on successive holes and the grout takes increased the pressure was reduced. Free communication of grout along the line was experienced first as dark gray water and then grout appeared. For the grout takes and conditions encountered in section I, see figure 21. With consideration of possible hydraulic jacking, the unknown depth and conditions of the openings encountered, it was decided to drill the secondary series in three stages. The first stage was to a depth of 9 feet. The second stage from depths of 9 to 15 feet, and the third stage to the bottom of the grout curtain.

(3) The secondary series split the primary spacing reducing the center to center spacing along the grout line to 5 feet. Pressures were maintained at 3 psi. For the first stage, the desired low pressure was attained by gravity flow from the grout plant. The bedrock was tight. The second stage was then drilled and the grouting was accomplished with 5 psi of pressure. Again open hole conditions were encountered with communication between some holes. As a final check tertiary holes were drilled to the entire depth of the line. The bedrock was tight and the section was completed. When foundation cleanup operations reached this area, it was observed that many of the open joints contained grout as far as 50 feet upstream and downstream from the grout line. However, these were thin joints and no evidence of the relatively large grout takes was apparent. The excavation for the outlet works structure was dry and conditions are apparently tight (see photos 45 and 46). A six-inch diameter core hole was drilled through the grout line at station 90+44 and no grout was encountered, indicating that no horizontal jacking had occurred.

b. Section II

(1) Primary holes. Section II, the slope section of the grout curtain extended almost the entire length of the 1V on 1H back slope of the right abutment cutoff. Access to this section was difficult. This problem was solved by building a wooden stairway the entire length of the cut. A power winch was anchored at the top of the cut and a rubber tired platform was pulled up the slope by means of a cable. The drill was mounted to this platform and drilling operations were completed using this setup. The upper zone of section II was 7 feet in depth. The holes were drilled with an NX bit to facilitate an NX packer for grouting the lower zone. The hole size was reduced to 1-1/2 inch diameter or "E" size from that point to the bottom of the hole. Grout takes in the lower portion of the slope were negligible. However, some takes associated with the anticipated seepage zones were experienced. The upper portion of the slope did present some difficulties in the grouting operation as the A zone of the Fort Riley limestone and one zone of the Holmesville shale required slush grouting and caulking (see figure 22).

(2) Pressure test. Pressures in the upper zone of section II were generally between 2 and 5 psi. During the grouting of the lower zone pressures varied from 10 to 60 psi. The amount of grout injected in this zone was less than had been anticipated. Voids in the bedrock in this section were probably partially grouted during the early experimental grouting nearby. Section III served as an overlapping interval of the test section. The holes of this section were drilled at an angle of 30 degrees to the vertical and penetrated an area previously grouted during the early test program. The holes were drilled into the C zone of the Florence, penetrating all of the major seepage zones. Some small takes were experienced; however, the major problem was in the Towanda limestone which is at the surface. This member, with numerous open bedding planes and fractures, was difficult to grout. For details of grout sections II and III see figure 22. In general, the right abutment curtain was completed on a hole spacing of 10 feet. The grouting of section I did require a smaller interval, and in some areas section II and III were grouted with a secondary series in areas where grout takes were experienced.

3-03. Left Abutment Grout Curtain.

a. Description. The left abutment grout curtain extends from station 142+00 to station 143+78. The grouting zones are similar to those of the right abutment with the slope portion being divided into two zones. For the location of this area and its sections see figure 23. The bedrock units grouted in this area are the same units grouted in the right abutment with the exception that the backslope is at a lower elevation and the Fort Riley Zone D, the Holmesville shale, and the Towanda limestone are not present. The bench on the Blue Springs shale was grouted. This bench area designated as section I extended from the lip of the bench to the toe of the back slope of the cutoff. All holes in this area were drilled the entire zone depth and similar grouting operations were used. Pressure testing and grouting operations in section I indicated that the bedrock was relatively tight. Holes in this section penetrated the Blue Springs shale, the Kinney limestone and into the upper Wymore shale. For the conditions encountered in this section see figure 23. Section II completed the left abutment curtain extending up the backslope and overlapped the completed left abutment test section. The slope portion was grouted in two zones. The upper zone, with a depth of 7 feet, was drilled with an NX size bit to facilitate, a packer for grouting the lower zone. An "E" size of 1.5 inch diameter hole was drilled to the bottom of the curtain.

b. Grout injection in section II of the left abutment grout curtain was negligible. Some caulking of open joints was necessary on the slope; however, there were no unusual problems. The grout plant was a standard grouting layout equipped with a 20 cubic feet mixing vat, 20 cubic feet storage vat, water meter and slush pump with a rated capacity of 50 g.p.m. at 150 pounds of pressure per square inch (see photo 47). All couplings and fittings were 1.5 inch ID. The grout tree of the header was equipped with bypass, bleeder valve and pressure gage. Gages used in most cases were 30 pound maximum gages. Pressure testing was accomplished through the header with a water meter inserted between the hole and the header in the line (see photos 42 thru 44). The grout curtain sections were completed satisfactorily and a relatively tight curtain was achieved.

CHAPTER 4

OUTLET WORKS

4-01. Excavation General. The excavation of the bedrock material from the outlet works area was accomplished with an electric-powered Marion shovel with a dipper capacity of 7.5 cubic yards. Hauling equipment consisted of Euclid end dump trucks with a capacity of 30 cubic yards. A Northwest 95 crane was also employed in excavating the stilling basin area and dressing slopes. Scraper equipment was used to dig the intake channel and portions of the outlet channel. The major portion of the bedrock material excavated from this area was placed in the shale and limestone zone of the upstream blanket. Later, as the embankment progressed the material was placed in the shale and limestone fill zone of the embankment. The outlet works excavation was completed in 8 lifts with 86 shots using approximately 260,000 pounds of explosives. The rock excavation totaled approximately 535,000 cubic yards. The excavation was made in the right abutment extending 1,800 feet (from approximately 700 feet upstream of the dam centerline to 1,100 feet downstream). The excavation encountered all members of the local geologic column. The cut slopes varied from 0.5V on 1H to 1V on 1.5H. Lift diagrams are shown on figures 27 thru 31. The slopes of the cutoff and the approach channel were pre-split. The other slopes were cut by conventional blasting methods. The two blasting methods will be discussed later in the report. In the upper portion of the cutoff area the Towanda and Holmesville members were ripped with a D-9 dozer. Blasting operations were started in that area at the top of the Fort Riley member. The thin residual overburden and the outer portion of the Blue Springs shale were excavated with scrapers. The remainder of the cut required blasting.

4-02. Primary Blasting.

a. General. The primary-blast lifts were limited to a depth of 26 feet by the capacity of the rotary drill used for drilling the blast holes. This drill, a Chicago Pneumatic 705, used a rock bit 4.5 inches in diameter. The drilling rate for this equipment ranged from 200 to 300 feet per hour with an average rate of 250 feet per hour. The Contractor attempted to bottom the lifts immediately below the hard and more massive ledges. The bottom of the lifts reflected the slight dip of the bedrock. Air trac drills with a 2.5 inch diameter rock bit were also used for drilling primary blast holes. In the lifts involving the cherty Florence limestone, the rotary drill was unable to penetrate satisfactorily. Elsewhere in the primary blasting, air trac drills were used when not needed in drilling pre-split holes. The smaller diameter holes drilled with this equipment required a closer shot pattern spacing. The blasting agent used for the bulk of the excavation was ammonium nitrate with a dynamite primer. One stick of 40 percent dynamite was used in the initial blasting; later one stick of 60 percent dynamite was used. The typical loading column for primary blasting is shown on figure 4. Electric delay caps were used as detonators with a 25 mili-second delay interval. A typical shot used delays ranging from instant to number 5. Primacord was used for some shots, but this was generally only when wet conditons were encountered. The ammonium nitrate was poured and tamped into the holes generally to within four feet of the top of the hole and the remainder of the

hole was stemmed with rock dust. In wet holes, the nitrate was first put into plastic bags and then placed in the hole. This method was replaced in later shots by use of a commerically tubed nitrate called "Dynatex." Most of the shots in the stilling basin area below the flood plain level were made with a gelatine dynamite with strengths ranging from 40 to 60 percent in standard stick size. A 45 percent gelatine dynamite with a high water resistance in 4 x 8-inch sticks was used when extremely wet conditions were encountered.

b. Shot patterns and loadings varied with the bedrock conditions in the various lifts. Each shot was recorded as shown on figure 5. The blasting record listing each shot for the outlet works excavation is shown on tables 1 thru 7.

(1) Lift 1. The "A" zone of the Fort Riley limestone was shot separately in the first lift with a pattern spacing of 7 x 9 feet and a powder factor of 1.2 pounds of explosive per cubic yard of rock. This lift was "overshot" and adjustments were made in succeeding lifts. The "B" and "C" zones of the Fort Riley were shot together in one lift and, although this was a slightly harder interval than the upperlift, the powder factor was reduced to 0.9 pounds per cubic yard using a shot pattern of 9 x 12 feet. When excavated, this lift showed improvement, particularly in the reduction of overbreak in the back slope.

(2) Lift 2. The second lift included the deepest shots made during the excavation in this area involving the "D" and "E" zones of the Fort Riley, Oketo shale, and "A" and "B" zones of the Florence limestone. This lift was also shot with a powder factor of 0.9 pounds per cubic yard with a pattern of 7 x 9 feet. This pattern and loading resulted in considerable oversize material, requiring secondary breakage, chiefly from the two rimrock ledges involved. The influence of the joints in the Florence member were notable in the back slopes of this shot resulting in the formation of benches and vertical faces. This condition was not observed in the slopes that had been pre-split.

(3) Lifts 3 and 4. The remainder of the Florence limestone was shot in the third and fourth lifts. The "C" zone was very susceptible to fracture and with blasting experience gained in the left abutment cutoff (shot No. 29) the fourth lift was shot with a considerably lower powder factor of 0.65 pounds per cubic yard, on a pattern spacing of 9 x 12 feet with good breakage and back slope conditions.

(4) Lift 5. The "A" zone of the Blue Springs shale was shot in lift five (shots 68 thru 71). Because this was a soft shale material, the pattern spacing was increased to 10 x 14 feet and the powder factor reduced to 0.55 pounds per cubic yard. The depth was governed by the foundation grade and the restrictions of blasting above it, particularly in the tower area.

(5) Stilling basin.

(a) Blue Springs shale. The remaining shots involved excavation of the stilling basin. Dynamite was used in this area due to the harder limestone zones of this interval and water problems. The lower Blue Springs shale was shot in one lift. The shot pattern was reduced from the preceding lift to a spacing of 8 x 12 feet and the powder factor was increased to 0.6 pounds per cubic yard.

(b) The Kinney limestone and the extreme upper Wymore shale were shot in one lift. Because of the relative hardness of the Kinney limestone, the shot pattern spacing was further reduced to a spacing of 6 x 10 feet and the powder factor increased to 0.7 pounds per cubic yard. This lift resulted in some significant overbreaks in the side slopes of the stilling basin excavation. The remainder of the Wymore shale interval and the upper Schroyer limestone were shot in the succeeding lift with a pattern of 9 x 12 feet and a powder factor of 0.4 pounds per cubic yard. The shale interval presented no problems in excavation; however, the hard ledge in the Schroyer below had to be re-shot with the next lift.

(c) The Schroyer limestone near the base of the stilling basin excavation was shot with a pattern spacing of 6 x 8 feet with 45 percent dynamite and a powder factor of 0.8 pounds per cubic yard. Final grade was obtained with "adobe" shooting the last 2 feet of the lift. The results of this method were generally good although isolated areas required the removal of fractured limestone. These areas were few and shallow.

c. Pre-split blasting. Pre-split blasting was employed in the excavation of the cutoff area slopes and in the approach channel area adjacent to the intake tower structure. These areas are shown on figures 27 thru 31. The results obtained by this technique ranged from satisfactory to excellent.

(1) Experiments throughout the work produced only minor variations in the finished slopes. The main problem was the primary blasting. Changes in the stemming, loading and spacing of the holes in the pre-split line sometimes resulted in excessive heaving and fracturing, creating a problem of drilling shot holes for the excavation blasting. The fracturing of the primary blast area can also present problems in shooting when ammonium nitrate is used, as at this project, where blasting efficiency depends on tight shot holes. The pre-split blasting of the outlet works was done making use of experience gained in test shots made in the left abutment area. These shots were made to determine the most effective column loading and to minimize excessive heaving and fracturing. As work progressed, the center to center spacing was increased and ultimately pre-split shots and primary blasting was combined utilizing delays. This method is called "pre-split delay." It is the only change from the test shot in which the column loading was established and was employed as an economy measure.

(2) Equipment. Chicago Pneumatic, air trac drills with three-inch diameter standard rock bits were used on all pre-split drilling. The cutoff slope holes were drilled at an angle of 25 degrees from the vertical. All holes were drilled "on grade." The usual problems of angle drilling were

encountered such as maintaining proper alinement and hole depth. Specified angles, however, were "held" remarkably well. Drilling rates varied from less than 10 feet per hour to a maximum of 120 feet per hour. The overall average drilling rate was approximately 50 feet per hour.

(3) Blasting. A 30-inch center to center spacing along the pre-split line was used successfully from the first shot. This spacing was later increased to 42 inches and resulted in little difference in the finished slopes. Upon excavation it was found that "bit drift" had resulted in an average angle of 48 degrees in holes started at a 45 degree angle, or a deviation of 3 degrees. The greatest deviation was 7 degrees or a 52 degree angle. These deviations due to "bit drift" were found to begin at a depth of approximately 20 feet. Drilling errors produced occasional undercuts and overcuts; however, these were sporadic and generally within specified tolerances. Initial pre-split shots were made in the left abutment cutoff area with the number of holes held to a minimum in each shot. Standard loading consisted of one stick of 40 percent dynamite tied at the end of a branch line of Primacord cut to a length corresponding to the depth of the shot hole. Full or half sticks of 40 percent dynamite were taped at specific intervals to the Primacord completing the explosive column as shown in figure 6. After holes were blown clean, these explosive strings or "pig tails" were lowered into the hole and stemmed at the top, generally with dry rock dust, as shown in figure 6. Loading difficulties were experienced depending upon hole conditions. Water was used as a lubricant to ease loading in some holes. The branch lines were then tied to the main truck line and detonated by an electric cap. More than one cap was sometimes placed in the trunk line. The explosive string in each hole was generally identical for an entire shot. The explosive column varied in the spacing of the individual dynamite sticks. The loading columns of these test shots are shown in figure 6. The finished slope of each test shot was identical but the heave and fracture of the primary blasting area did vary. The stemming and explosive column of each test shot were adjusted and the third shot was used as a basis for subsequent pre-splitting. Photo 4 shows a successful pre-split shot made for the second lift of the left abutment cutoff. The first shots were to a depth of 25 feet, penetrating the Fort Riley and the Oketo members. For the second lift in areas being pre-split, a work area four feet wide was required (see figure 7). These benches mark the top of each lift in the finished slopes; however, they were eliminated in the approach channel area by pre-splitting the entire lift.

d. Pre-split-delay blasting.

(1) Description. Standard pre-split loading procedures were used in pre-split-delay shooting. The difference between the two techniques is that in standard pre-splitting the pre-split row is shot prior to the loading and in some cases the drilling of the primary blast holes while in the pre-split method the pre-split row and the primary blast holes are detonated together employing delays. The pre-split holes are detonated by an instant caps connected to the trunkline Primacord, or where a great number of pre-split holes is required, instant caps are attached at each end assuring instant detonation throughout the row. The front row or face holes are also detonated instantly with the pre-split row and successive primary rows are progressively delayed toward the slope (see figure 8). At this project the

greatest delay employed between the back row and the pre-split row was a number 4 delay or 100 milliseconds. The pre-split holes were generally drilled deeper than those of the primary series as shown on figure 7. Only the portion of the slope corresponding to the depth of the primary blast holes was subjected to delayed pre-splitting. The portion of the slope below the primary blasting areas was left undisturbed as the remainder of the slope was pre-split to the desired depth. After the lift was "mucked out" primary blasting was then employed to remove the remaining material as in the standard pre-split procedure.

(2) The back row of primary blast holes was no closer than two feet above the pre-split fracture zone. This interval appeared sufficient for both types of pre-splitting. The interval was particularly critical in the pre-split-delay procedure with the possibility of this row "kicking" downward, due to fracture and lift adjacent to the pre-split fracture zone.

(3) The use of the pre-splitting technique resulted in relatively smooth slopes in the cutoff areas of the abutment for the embankment tie in (see photos 5 and 6). It also reduced the amount of cleanup required. The pre-split slopes showed improved weathering resistance over those cut by conventional blasting methods especially in the Florence member which was particularly susceptible to spalling in the conventional cuts.

4-03. Foundation, General. Initial foundation work started in the approach channel area and progressed downstream. Approximately eighty percent of the foundation bedrock beneath the structure is shale belonging to the Blue Springs and Wymore members. All shale portions of the foundation were covered with a lean concrete pad with a minimum thickness of six inches. This pad was placed within a few hours of final cleanup operations. The remaining portion of the foundation bedrock is limestones as follows: a thin ledge in the central section of the Blue Springs member, the Kinney limestone member, and the Schroyer limestone member. These limestones required no protective lean concrete pad and foundation cleanup was relatively simple with the exception of an occasional area where blast holes had been drilled too deep. For a general geologic section beneath the structure see figure 9.

4-04. Shale Foundation.

a. General. The weaker materials encountered in the foundations were the red and green clay shales of the upper Blue Springs member, and the lower Wymore. The red zones of the Blue Springs member were somewhat harder than their green counterparts. The Wymore B zone was similar to the soil zone of the Blue Springs with the exception of the extreme lower part which exhibited an increase in calcium carbonate cementation progressing toward the base of the member. This resulted in a competent shale foundation. It was within this area that the only continuous gypsum seam in the foundations was observed. This was a seam of satin spar three quarters to one inch thick which extended across the entire foundation for the O.G. section at station 4+58 downstream. The seam was tight with no evidence of ground water solution work (see photo 8). Foundation cleanup of these zones presented no problem when opened and covered with lean concrete in a reasonable time, i.e., a few hours. It was found generally that final cleanup with air only and a light water spray after cleanup produced the best results.

b. Blue Springs zone A. From station 4+25 (upstream) to 3+76 (upstream) the Blue Springs zone A predominately a green shale, forms the foundation surface for the downstream portion of the approach walls, the entire approach slab, and the upper portion of the tower key vertical surface (see photos 9 thru 11).

c. The Wymore zone B forms the foundation surface beneath the lower portion of the O.G. section from station 4+33 (downstream) to station 4+61 (downstream). It was encountered from elevation 1037 to elevation 1050 m.s.l. (see photos 12 and 13).

d. Blue Springs zone B. The extreme upper portion of the Blue Springs "B" zone formed the major portion of both vertical surfaces of the tower key at station 3+76 U.S. and 3+46 U.S. and the surface beneath the remainder of the tower and the transition section from station 3+76 U.S. to station 1+77 U.S. (see photo 14). This surface did not deteriorate as rapidly as the materials previously described and if covered in a reasonable time would not have been subjected to air slaking. However, the Contractor delayed pouring the lean concrete due to plant difficulties and the surface spalled badly. This material spalled in fragments similar in size and shape to peach seeds and several cleanup operations were required. Burlap was used to cover the surface which was kept continuously wet; however, a final air-water cleanup operation was needed immediately prior to the placement of the lean concrete pad. This material was better suited for the air-water cleanup process. Enlarged joints encountered in this zone complicated the cleanup operation. The remainder of the B zone of the Blue Springs shale is a firm, dark gray, calcareous shale. This material approaches a limestone consistency in a thin limey fossiliferous zone in the upper portion. It was the only prominent fossil zone encountered during excavation operations. This horizon formed the floor of the tower key from station 3+76 U.S. to station 3+46 U.S. and was an excellent foundation surface (see photo 15). The zone B shale forms a good firm foundation surface for the entire conduit from station 2+35 U.S. to station 3+80 D.S. Typical foundation and collar excavation is shown in photos 15 and 16. The "B" zone shale was well suited for the air-water cleanup process and could be kept in good condition indefinitely if kept continuously wet. An occasional cleavage plane was encountered and is shown on the main foundation map. Adjacent to these cleavage planes, as well as joints, drummy areas were sometimes found (see photo 18).

e. The Wymore shale zone A is the most competent shale encountered in the outlet works foundations. It forms the foundation surface beneath the O.G. section from station 4+11 D.S. to station 4+33 D.S. It is a hard, gray, calcareous shale but is susceptible to fracture. It is comparatively resistant to weathering. However, during the blasting operations, shot holes were drilled too deep in the O.G. foundation. This required considerable removal of fractured material below grade and backfilling with lean concrete. When all fractured material had been removed this zone produced an excellent foundation surface as shown on photo 19.

4-05. Limestone Foundation.

a. General. The limestone ledge in the "A" zone of the Blue Springs shale member was encountered at a general elevation of 1078 in the approach channel area. It consists of a single ledge one foot thick and forms the foundation surface for the upstream portion of the approach walls. See photo 10. The limestone is hard and generally light gray. It lies above the foundation grade downstream of station 4+25 D.S.

b. The Kinney limestone forms the foundation for the structure between stations 3+80 D.S. and 4+10 D.S. in the upper portion of the O.B. section. This is a hard, medium gray limestone and easily cleaned by air-water jetting. The Contractor experienced considerable trouble with this bed because it was undercut and was difficult to remove. Between stations 4+60 D.S. and 6+02 D.S., the Schroyer limestone forms the foundation surface for the extreme lower O.G. section, the floor of the stilling basin, stilling basin walls, and the end sill. The upper three feet is hard, white, limestone overlying seven feet of dark shaly limestone. Most of this member is found in the vertical surface of the end sill at station 6+02 D.S. This surface contained two chert layers and zones of gypsum nodules (see photos 20 and 21). The thin cherty limestone of the lower Schroyer forms the major portion of the foundation surface for the stilling basin walls and floor. This limestone is 0.8 feet thick and is hard affording and excellent foundation surface. In some areas the excavation operation broke through this ledge into the softer dark gray argillaceous material below. This generally was due to the Contractor's attempt to divert water to a sump in the upstream riverward corner.

c. The Schroyer limestone formed a good foundation surface. Cleanup operations were simple. An occasional blast hole was drilled too close to grade, and fractured rock was removed from small areas. (See photos 22 and 23.)

4-06. Foundation Jointing.

a. General. Extensive bedrock jointing was encountered during foundation preparation beneath the upstream portion of the structure. Each individual joint and fracture was mapped as to strike, condition, and seepage as shown on figures 10 thru 13 and on figures 33 thru 39. Three sets of joint trends were recognized. The major trend was N70°E and the minor trend varied from N40°W to N50°W. A third set trends N85°E and parallels the outcrop face (see figure 10). The third trend reflects the mechanical adjustment of the bedrock zone adjacent to the outcrop face due to the erosion of the river valley. All joints were vertical in the foundation and ranged from tight to open several inches. Seepage from the joints was minimal and was generally confined to the upstream sections below elevation 1075.

b. Approach channel. The Blue Springs shale zone A in the approach channel area exhibited good joint development. All three trends were present. A detailed map of this area is shown in figure 11. The joints were generally tight or filled with a soft clay. The major exception was an open joint which extended from station 4+22 U.S. to station 1+52 U.S., paralleling the south approach wall. This joint extended through the approach slab foundation, the upstream vertical key surface, and through the remainder of the tower area and beneath the conduit. The joint had been enlarged by ground water to an average width of 4 inches and extended down into the top of the "B" zone below, where it had a one quarter-inch opening in the floor of the tower key. Water was seeping from the upstream portion and the joint faces were water marked indicating a prolonged period of ground water movement. Adjacent drummy shale was removed and the walls were shaped back into a "V" notch. The "notch," when cleaned, measured approximately 2 feet wide and 3 feet deep (see photos 24 and 25). In the floor of the tower key, joints trending N85°E were concentrated in the south half and ranged from tight to open (up to one-half inch). Water seepage from these joints was small. One fracture trending N70°E was traceable. It extended from the downstream wall of the key into the approach channel area (see figure 12).

c. Tower and transition. The joints of the tower and transition areas were similar to those in the approach channel and were treated in the same manner (see photos 26 and 27). Open joints ranged from 1 to 2.5 feet deep. Original joint openings ranged from tight to open several inches. Some were completely open and some were partially filled with soft clay and large gypsum nodules. For a detailed map of these joints and their relationship to the structure see figures 11 thru 13 and figures 32 thru 39.

d. Conduit. Joints of the lower Blue Springs "B" zone beneath the conduit generally trend N85°E. These were open about one-half inch and produced occasional small amounts of seepage in the foundation floor particularly in the collar excavations. The foundation was dry in the vicinity of the grout curtain with no seepage noted for 50 feet on either side of the dam axis. Grout filling was observed in many of the joint openings in this area. Downstream of the dam axis, the major joints trend N60°E. The Kinney limestone exhibited joints of the minor trend (N40° to 50°W). The foundation area, however, was located far enough landward that the enlarged weathered joints of this member occurring in the riverward area were not present. In the upper portion of the Wymore shale zone B some joints of the minor trend were encountered. This horizon showed some evidence of groundwater work but no seepage was experienced in the foundation area. Jointing in the Schroyer limestone was poorly developed. Only a few joints of the minor trend were found and were traced only a short distance.

CHAPTER 5

SPILLWAY

5-01. Excavation General. The spillway is formed by a rock cut located 3,000 feet south of the embankment. It is an uncontrolled emergency chute type with a concrete sill. It is 1,250 feet wide at the crest and 4,800 feet in length. The depth of this excavation varies from 0 to 54 feet. The side slopes vary from 1V on 1.5H in rock, to 1V on 3H in the overburden. The centerline of the concrete sill is located at dam station 24+00 as shown in figure 14. The slab is 50 feet wide and 3 feet thick, extending across the spillway and up both slopes to elevation 1206. This slab is secured with grouted anchors, shale protection slabs, return walls, and 48-inch riprap is placed upstream and downstream from it. The spillway cut required excavation of 4,365,000 cubic yards of material consisting of 2,090,000 cubic yards of overburden and 2,265,000 cubic yards of rock. After first stripping the vegetation, which involved the removal of approximately four to six inches of the top soil, the clay overburden was excavated by means of 40 cubic yard scrapers. This excavation method continued through the top of bedrock into the upper Towanda limestone. A 60,000 pound ripper was also used. The bedrock excavated was used for shale and limestone fill. The better quality Towanda limestone was excavated separately and used as rock fill adjacent to the tower and stilling basin, in the Towanda limestone fill beneath the riprap and as bedding material. These materials were produced from the hard limestone zone in the middle section of the Towanda member (see photos 40 and 41). Towanda limestone of marginal quality was utilized as slope surfacing in the protective layer of the downstream slope of the embankment. The bulk of the blasted bedrock material in the spillway was excavated by an electric powered Marion shovel with a 7.5 cubic yard dipper. The shovel had an average loading time of 20 cubic yards per minute (see photo 39). Euclid end dumps with a capacity of 30 cubic yards were loaded by this shovel in about two minutes. The average hauling distance to the embankment was 6,00 feet and required about 15 minutes per round trip including dumping. This equipment is shown in photo 40. Excavation of the spillway was scheduled to meet the fill requirements of the embankment with the exception of the crest slab area which received priority to coincide with concrete scheduling. The excavation was generally completed to grade in a single operation except where the utilization of Towanda limestone only, was required. Excavation of the key trenches beneath the sill was completed by a backhoe. The loess blanket covering bedrock in the spillway was a lean clay with a typical moisture content of 19 percent. It was used as impervious fill in the upstream blanket and in the embankment core.

5-02. Blasting.

a. General. Blasting of the Towanda and Holmesville was, in general, completed in one lift to the spillway flow line. The lift varied in depth from 8 to 20 feet with a blasting pattern of 11 x 14 feet. Ammonium nitrate was the blasting agent, using one stick of 40 to 60 percent gelatine dynamite as a primer. Primacord was used particularly when wet conditions existed. During periods of rain, wet holes were loaded with Gelamite (4 x 6 inch of 45% gelatine dynamite). Shot records cannot be found or none were kept.

b. The loading column was varied with the anticipated utilization of materials. In areas being shot for shale and limestone, the Contractor used a straight loading column of dynamite primer; 2 pounds of ammonium nitrate per lineal foot and 5 feet of stemming (usually rock dust). In areas where the Towanda limestone was utilized separately, deck loading was employed using Primacord with 8 pounds of ammonium nitrate in the Holmesvile, rock dust decking to the base of the better Towanda, and 21 pounds of nitrate with a stemming interval of 5 feet at the top. Breakage differences between the two loading systems was not apparent and the decking procedure resulted in eliminating only the shale heaves into the limestone sections above. For an illustration of the loading columns see figure 17. In blasting for the material that was to be crushed for bedding, the lift penetrated only to the base of the hard limestone zone or middle zone of the Towanda member. The lift was approximately 8 feet deep and was drilled with a pattern spacing of 7 feet x 11 feet. The excavation of the spillway bedrock involved approximately 175 shots. The powder factor was approximately 0.29 pounds of explosive per cubic yard of rock.

c. Blasting of the sill keys in the spillway involved the lower Holmesville shale member and upper Fort Riley limestone member. Prior to the excavation all vertical wall surfaces were line drilled. This was accomplished by air trac drills and a tractor mounted drill using 3 inch diameter rock bits and a rotary drill using a 4 inch diameter bit. Holes were drilled on one foot centers. After the completion of line drilling, holes were drilled for the trench blasting.

d. Blast holes (3 inch diameter) were drilled along the center line equidistant between the line drilled rows with a center to center spacing of two feet. A typical leading column for these holes is shown in figure 17, with two sticks of dynamite in the Fort Riley limestone and one stick of dynamite in the Holmesville shale.

e. Best results were obained when shots were held to no more than 6 holes using electric caps with instant to number 5 delays. Upon completion of the excavation, the side walls were cleaned and the Holmesville portion of these walls was protected with "gunite" and wire mesh.

f. Final grading of the floor was comparatively simple with the exception of areas where the upper hard limestone bed in the lower Holmesville protruded above the foundation grade. The bulk of the grading was accomplished with blade equipment.

g. Cleanup of the sill foundation was accomplished with air jets and was reasonably successful (see photos 29 thru 31). The slope section foundation cleanup was complicated by two factors; the Holmesville shale was excavated too close to grade and the foundations were left exposed an entire winter without adequate protection against freezing. Cold weather halted operations in this area at the end of the second construction season and the slope foundation already below the specified grade were subjected to freeze and thaw cycles until the next spring when operations were resumed. This resulted in considerable over excavation and high costs for labor and backfill concrete.

h. Slope foundations in shale were "stair-stepped" on horizontal cleavage planes in the Holmesville member. The final cleanup was accomplished with air-water jets, which resulted in good foundation surfaces (see photo 32). The Towanda limestone in the south slope presented no unusual problems; however, on the north slope during the excavation blasting, this member was badly fractured. All fractured rock was removed resulting in considerable over excavation. The limestone was "stair-stepped" on the numerous well developed bedding planes. It was cleaned with the air-water jets and good to excellent foundation surfaces were obtained (see photo 33). Lean concrete was also used tc backfill over excavation on the north slope.

5-03. Spillway Sill.

a. General. A typical cross section of the concrete sill is shown in figure 15. To prevent possible undercutting of the structure during spillway flows, two keys, 3 feet in width, were constructed beneath the slab as shown in photo 28. The upstream key extended downward just into the underlying Fort Riley limestone. The downstream key extended 18 feet below the slab to elevation 1158. Both keys extend up the slope portion of the slab to the ends of the crest structure.

b. The downstream key penetrated the Fort Riley zone "A" to its base on the north end and three feet above the base on the south end due to the local dip of the bedrock. The upstream key penetrated the Fort Riley an average depth of one foot.

c. Protection. In order to protect the Holmesville shale which is exposed nine feet above the flow line, concrete protection slabs were placed along the side slopes to the top of the Holmesville shale for a distance of 50 feet upstream and downstream of the main slab. These slabs were also keyed in to the top of the Fort Riley at the same general depth of the upstream key of the main crest slab. The keys were 2 feet thick and afford the Holmesville protection below flow line.

5-04. Spillway Sill Foundation. The lower Holmesville shale is the foundation for the crest slab. See foundation map plan and profile spillway, figures 40 and 41. The middle green zone in the south end and the two limestone beds of this member are the foundation toward the north end. For details of the foundation conditions beneath the main sill slab see spillway sill plan and profiles. Foundation of the upper slopes of the sill are Towanda limestone of relatively good quality. Riprap up to elevation 1085 on the north slope and 1083 on the south slope as well as the concrete slabs rest on the upper Holmesville shale.

5-05. Grouted Anchors.

a. Initial installation. After the lean concrete pad had been placed on the shale surfaces of the foundation, grouted anchors were installed. These anchors were installed by drilling a 6-inch diameter hole to a depth of 18 feet below the crest slab with a rotary drill (see photo 34). The holes were then cleaned with a combination of air and water, and filled with grout. Many holes lost grout into open solution channels of the Fort Riley "A" zone (see photo 35).

b. Testing. When the hole was filled with grout, number 10 reinforcing steel bars ("J" bars) were inserted and vibrated into position by placing a concrete vibrator against the bar. Additional grout was added when necessary. The anchor holes in the slope sections were drilled at an angle of 30 degrees to the vertical varying in length from 12 to 24 feet. The drilling of these holes was accomplished with air trac drills. For an illustration of the relationship of the anchors and slab see figure 15.

c. Deep anchors. Two rows of grouted anchors were placed through the concrete protection slab keys at an angle of 30 degrees to the vertical. This operation was difficult, requiring angle drilling of a hole large enough to pass the neck of the anchor through the key and into the shale below. This was accomplished by drilling two six-inch diameter holes "piggy back" into the key and then drilling out the wall section between the holes. These oversize holes were then backfilled with concrete after the anchors had been placed into the key wall (see photos 36 and 37).

5-06. Riprap. Additional slope protection is afforded by a 48-inch layer of riprap extending 50 feet upstream from the upstream protection slabs and 425 feet downstream from the downstream slab. A detail of the riprap is shown in figure 16.

CHAPTER 6

RELIEF WELLS

6-01. General. Along the downstream toe of the embankment, a total of 73 relief wells were installed for control of underseepage. These wells are designed to produce an artesian flow as the pressure builds in the alluvial foundation of the embankment. A series of collector and header ditches carry the flow from the toe of the embankment to the downstream borrow pits.

6-02. Well Design. The well consists of an eight-inch ID wood screen and riser of treated Douglas fir. The screen section consists of wood staves banded with galvanized wire with milled 3/16-inch slots in offset pairs constructed with open area of 25 to 30 square inches per lineal foot. The joints connecting the various sections are of the mortise-male type held together by brass screws. The riser is of similar construction without the slotted openings. The screen generally extends from two feet above the bottom of the well to a point approximately two feet below the top of the sand aquifer. The riser then extends from this point to the well header. The screen is encased within a gravel pack with a minimum of six inches of gravel between the screen and the foundation sands. The gravel pack extends from the bottom of the well, two feet below the screen to a point at least two feet above the screen near the top of the aquifer. Above the gravel pack around the riser section is a one-foot thick layer of concrete sand and gravel pack. The purpose of this layer is to relieve pressure in the upper layers of material too fine for the gravel pack, and to prevent the concrete in the collar above this layer from penetrating. A concrete collar was placed around the riser to a point just below the metal well header. The well header consists of a corrugated metal tee with an outfall and a riser extension. The outfall extension discharges into the collector ditch just above the flow line. Both the riser and the outfall extension openings are protected by galvanized flap gates (see figure 24).

6-03. Well Installation.

a. Drilling equipment. Well construction began with drilling a 24-inch diameter hole with a Mayhew reverse rotary drill rig. A 24-inch diameter cone shape fishtail bit was utilized with a drill string of eight-inch ID sections ten feet in length. This equipment is shown on photos 48 and 49. As drilling progressed, continuous samples were taken by sampling the discharge water and the hole was logged. A typical log is shown in figure 25.

b. Drilling. The wells were drilled to bedrock with the exception of the partial penetration wells designed to go only to a specified elevation, and wells between station 124+00 and station 135+00 which could not be drilled to bedrock due to a boulder and cobble layer.

c. The boulder and cobble layer created many drilling problems with larger cobbles plugging the bit. The wells were bottomed out upon refusal on a large boulder. As the drilling progressed to station 107+00, the layer appeared to be mostly cobbles with a few small boulders. At this point penetration to bedrock was accomplished. At station 116+00 the layer appeared

to be relatively level at about elevation 1040. In most cases a two to five foot interval of sand separated this layer from bedrock. The bedrock elevation varied from 1048 to 1028. The wells terminated on the Wymore shale member from station 92+50 to station 93+50 and from station 128+00 to station 140+00 on each end of the well line. From station 107+00 to 128+00 the Schroyer limestone member formed the bedrock surface. For a profile along the well lines, see figure 26.

d. Well placement. The wells were drilled on a center to center spacing of 75 feet from station 122+00 to station 92+50 and on a spacing of 50 feet from station 122+00 to station 140+00. In the latter area, every third well was a partial penetration well drilled to approximate elevation 1052. Upon encountering bedrock, the drilling tools were removed and a 24-inch ID temporary casing was placed in the hole to a depth approximately two feet below the top of the gravel pack elevation. This required about 17 feet of casing. The elevation on the top of the casing was noted and all subsequent work on the well was referenced from that point. The depth of the hole was then checked and the lengths of screen and riser sections were established.

e. Screen and riser sections were made up and the spiders (spacers) were attached. These were generally placed five feet below the bottom of the screen and three feet above the top of the screen. The bottom plug was driven into the bottom of the screen and secured with nails. The joints were secured with screws. Wood bracers and heavy gage wire were used to reinforce the joints (see photos 50 thru 53).

f. Gravel pack material was tremied into the hole to a depth of two feet above the bottom. The screen-riser assembly was then picked up by a crane and placed into the well and set on the gravel pack. The braces were removed as the assembly was lowered into the well. A third spider of heavy metal was placed around the top of the riser. This spider or collar was adjusted to fit tightly within the temporary casing. This helped to hold down the wood riser which tended to float. It also assured the centering of the riser during succeeding work operations. A heavy chain was then used to insure against slippage of the setup. The gravel pack was placed through a five-inch diameter aluminum tremie pipe. A hopper above the pipe was fed by conveyor belt. The conveyor was approximately 30 feet long, powered by a small gasoline engine. The hopper end (or feed end) of the conveyor was mounted on rubber tired wheels. A garden hose was placed in the tremie hopper and continually introduced water into the tremie pipe. The gravel pack material was shoveled by laborers into the conveyor belt hopper which in turn carried the material to the tremie pipe. When the tremie pipe was filled completely, it was lifted slightly and the material began slipping en masse into the hole. About 40 feet of gravel pack was placed in less than an hour. The well was bailed and the screen was cleaned out. The prescribed chemicals were then mixed in a tub with water and poured into the well. The bailer was then used to mix the solution by slowly raising it from the bottom to the top of the well. The well was then left undisturbed for a period of 48 hours. At the end of this period, the Contractor developed the well; however, the actual time varied with the Contractor's schedule and weather conditions. Generally the well was developed within a period of 60 hours after the chemicals were placed. A six-inch Western Roller turbine pump driven by an 8-cylinder

automobile engine was used for development. The bottom of the drop pipe was set at a depth of 24 feet which placed it generally six feet into the screen. The pump had a maximum rating of 500 g.p.m. with 50 feet of head. The static water level was measured with an M-scope, the line of this instrument was set for a drawdown of seven feet. The development was then begun by overpumping. In the large producing wells maximum drawdown was not attained. During the overpumping operation the water usually began clearing after one hour of "surging"; however, the wells continued to draw in fine sand for some time. Development time ranged from two to six hours. When the water in a jar sample was free of sand, the developing operation was considered complete. The drawdown was noted and an estimate of the final pumping rate was made (see photo 53). Once the well was developed, a sand-gravel pack mix was tremied into the well. This was brought up to an elevation generally corresponding with the bottom of the alluvial blanket. A concrete collar was placed above the sand-gravel pack to the specified elevation. Two methods of concrete placement were used. In some wells the water was pumped from the top of the sand gravel by hand with a pitcher pump and the concrete placed. In others the tremie method was used. The sand-gravel and the concrete backfill were brought up in increments of two feet and the temporary casing was pulled in the same intervals by a crane, taking care to keep the bottom of the temporary casing at least two feet below the backfill material. With the well backfilled, a check was made for the presence of fine sand drawn into the well by the developing operation. This generally ranged from a few tenths to two feet. It was removed by bailing prior to the pump test.

6-04. Pump Testing.

a. Testing. The same pump used for developing the wells was used for the pump test. The static water level was measured at each well along the well line and the pump test started. The initial drawdown was measured with an M-scope and timed with a stop watch. Continuous readings of the water level were taken on the well being tested and the adjacent well during the test. The pumping rate was measured using a 4-3/8-inch circular orifice on a six-inch ID discharge pipe. At the end of four hours the test was completed, the pump was shut off and the recovery of the water level was noted.

b. Results. In general, the wells were good producers with yields up to 200 g.p.m. per foot of drawdown. The partial penetrating wells did not produce as much as the deeper wells. For a profile along the well line see figure 26 and Plates 23 and 24.

CHAPTER 7

7-01. (a) Instrumentation consists of the following: Eleven Alinement monuments were installed in a line on 50-foot centers along range 1+75 Downstream. Five strong Motion Accelerographs were installed; one on the left abutment, one in the intake tower, one on the crest of the dam, one on the downstream slope, and one at the downstream toe. Seventy-three pressure relief wells were installed along the downstream toe. Three foundation settlement gauges and 7 crest settlement monuments were installed. Sixty-three piezometers, were installed. All are the open tube type. All but 5 have their tips in the foundation sands. The 5 remaining have their tips in the impervious clay core. Since installation, 61 of the piezometers have been continuously monitored. Extrapolation of data indicate the seepage control measures have maintained piezometric levels well below the design limits. The piezometers along the downstream toe are located midway between the pressure relief wells to aid in evaluation of the relief well's performance. They have their tips in the foundation sands and just below the base of the natural blanket. With the exception of two areas, the relief wells have been effective in holding the seepage pressures to levels only slightly higher than the elevation of the well discharge pipe. These relatively high pressures are near piezometer P-11B at station 110+90 and piezometer P-30B at station 133+80. On 3 October 1973, the record high pool was at El 1158.3, piezometer P-11B had a pressure head of 4.6 feet above the flow line of the relief well drainage ditch and piezometer P-30 had 4 feet. A small sand boil developed near P-11B. The boil was brought under control by constructing a sandbag channel block downstream of the boil, raising the water level in the ditch. Since the top of the relief well screens near the boil area is 18 feet below the ground surface, the presence of a shallow pervious zone could explain the higher pore pressure and thus the sand boil. In order to repair the high pressure area and relief well drainage ditch, a $35,000 contract (DACW-41-76-0045) was awarded to Bayer Construction Company in April 1976 when the pool was near multipurpose level (El 1144.4) and the pore pressures were lower in the repair area. From approximate stations 108+00 to 116+00 the ditch was deepened and lined with a 6-inch layer of pervious material and a 30-inch diameter, perforated corrugated metal pipe, wrapped with plastic filter cloth was installed. Connections were made to the outfall pipes of relief wells 20 thru 30. The pipe was covered with a minimum of 6-inches of sand followed by a minimum of 12 inches of impervious clay. To date (May 1978) the buried collector pipe appears to be working satisfactorily. Pore pressures and water flows from the wells are normal but high pool levels have not occurred since the repairs have been completed. See plates 24, 25 and 26, and Periodic General Inspection Report No. 5, (April 1974).

7-01. (b) Settlement Plates. Readings of the settlement plates thru April 1974 indicate the foundation settlement is essentially complete, 0.05 foot to 0.1 foot. The two valid readings to date (April 1974) of the crest settlement monuments indicate embankment settlement of 0.1 foot to 0.2 foot.

FIGURES

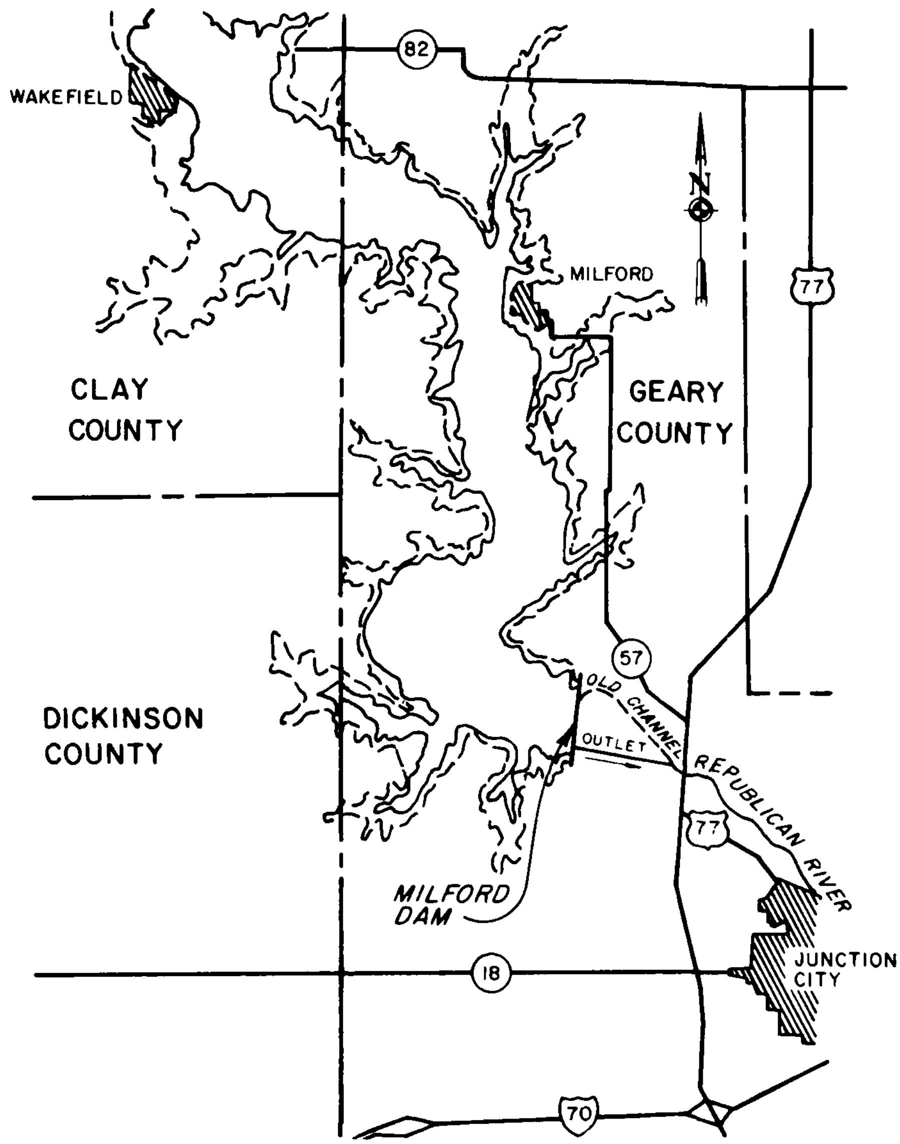


FIGURE I

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

LOCATION

In 1 sheet | Sheet No. 1 | Not to scale

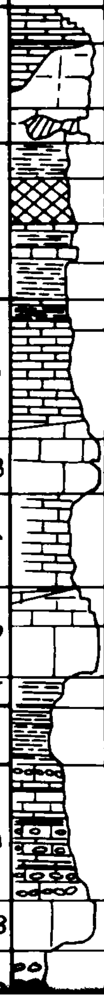
CORPS OF ENGINEERS U. S. ARMY

KANSAS CITY DISTRICT

FILE NO. B-1-1921

APRIL 1977

FIGURE I



GROUP	FORMATION	MEMBER	ZONE	THICKNESS	DESCRIPTION	CONSTRUCTION INVOLVEMENT AND UTILIZATION	EXCAVATION METHOD
MPIAN SERIES)	DOYLE SHALE	TOWANDA		4.0'	LIMESTONE: soft, Kaolinitic thin bedded white	Sh & Ls fill	Ripped
				8.0'	LIMESTONE: hard, medium-thick bedded, gray fractured	TOWANDA LS. fill Bedding, rock fill, slope surfacing	Spillway Blasting
				3.0'	LIMESTONE: hard, w/ solution zone, clay filled	Slope surfacing	14x21 A.H. .4; 7x11 A.H. 1.5
		HOLMESVILLE		4.0'	SHALE: soft, yellow-brown calcareous	Sh & Ls. fill	
				5.0'	SHALE: green, moderately soft, calcareous	Spillway floor	Ripped (O.W.)
				4.5'	SHALE: soft, dark gray, w/ two hard vuggy ls beds	Sh & Ls fill	
				4.0'	SHALE: soft, dark gray conglomeratic, green base		
	BARNSTON LIMESTONE	FORT RILEY		3.0'	LIMESTONE: soft, tan, w/ alternating green shales		Blasting (O.W.)
			A	12.0'	LIMESTONE: moderately hard, tan, thin bedded to occasionally medium bedded, leached, min. solutioned	Sh & Ls fill	7x9 A.H. 1.2; Pre-split (O.W.); Quarry Blasting
			B	5.0'	LIMESTONE: hard, tan two beds, separated by open bedding plane, vuggy	Seepage zone Sh & Ls fill	L.A.C.; 42" c-c 40% ½@18
			C	10.0'	LIMESTONE: moderately hard, dark gray, thin bedded	Sh & Ls fill	9x12 A.N. .9; 11x16 A.N. .4
			D	4.0'	LIMESTONE: hard, tan medium bedded	Sh & Ls fill	
				5.5'	LIMESTONE: hard, lt tan massive, pitted, vuggy	Seepage zone Riprap Ledge	30" c-c 40% ½@18; 4x6 30 .45 .3; 42" c-c 40% ½@18
			E	3.0'	LIMESTONE: hard, tan, shaly, massive	Sh & Ls fill	7x9 A.N. .9
		OKETO		6.0'	SHALE: moderately hard, dark gray, calcareous	Sh & Ls fill	
		LORENCE	A	15.0'	LIMESTONE: hard, tan, medium bedded, contains chert nodules in bands alternating shaly zones	Sh & Ls fill	30" c-c 40% ½@18; 42" c-c 40% ½@18
			B	5.0'	LIMESTONE: hard, tan, massive, pitted, vuggy @ base	Sh & Ls fill seepage zone	42"
					LIMESTONE: hard, tan, massive w/numerous		

Spillway slopes

D.S. sill key

U.S. Key

Back wall Right Abutment cutoff

Back wall Left Abutment cutoff (Pr

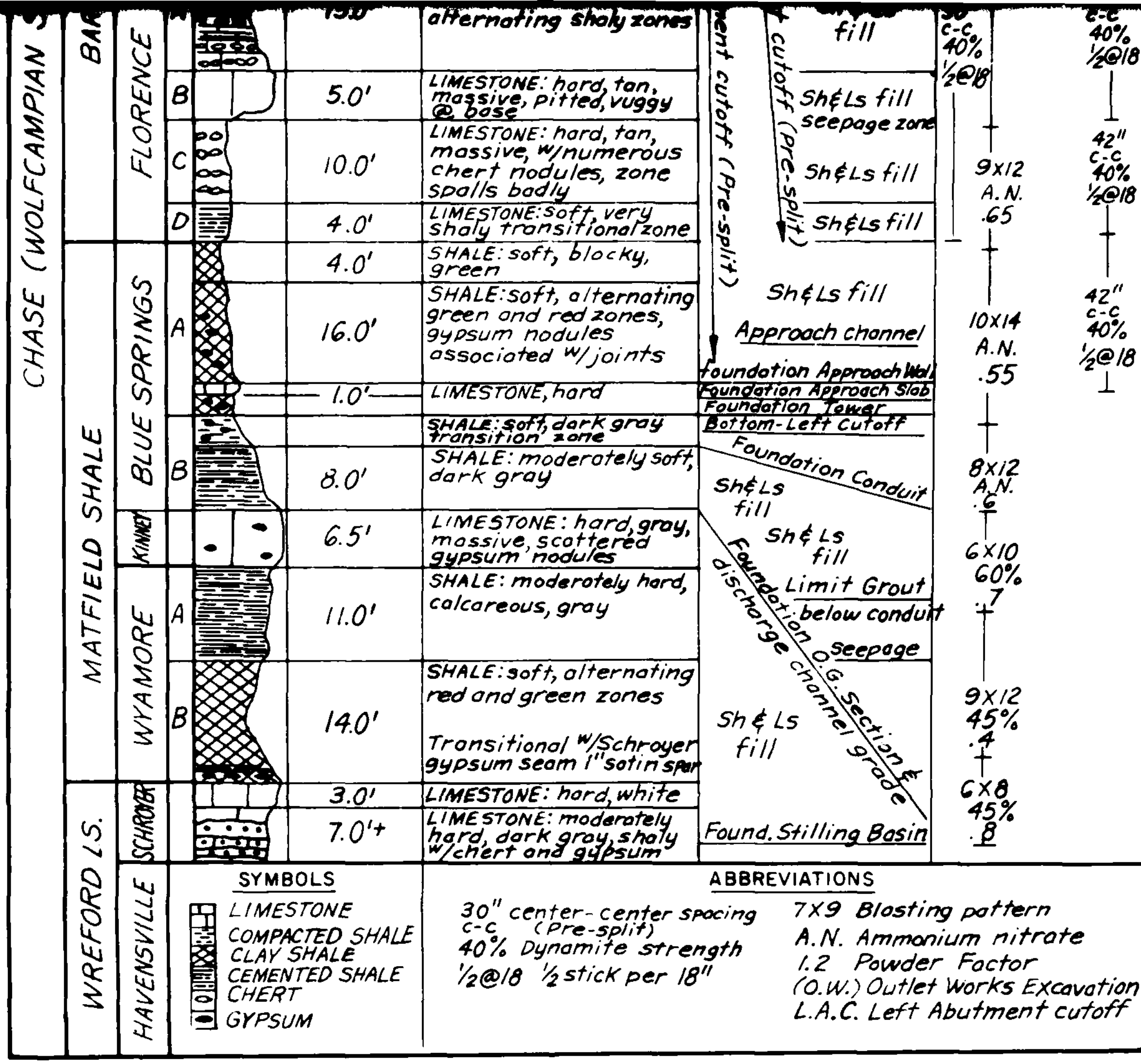


FIGURE 2

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

GEOLOGIC COLUMN AND UTILIZATION SUMMARY

In 1 sheet Sheet No. 1 Not to scale

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KANSAS CITY DISTRICT

FILE NO. B-1-1922

APRIL 1977

FIGURE 2

1

2

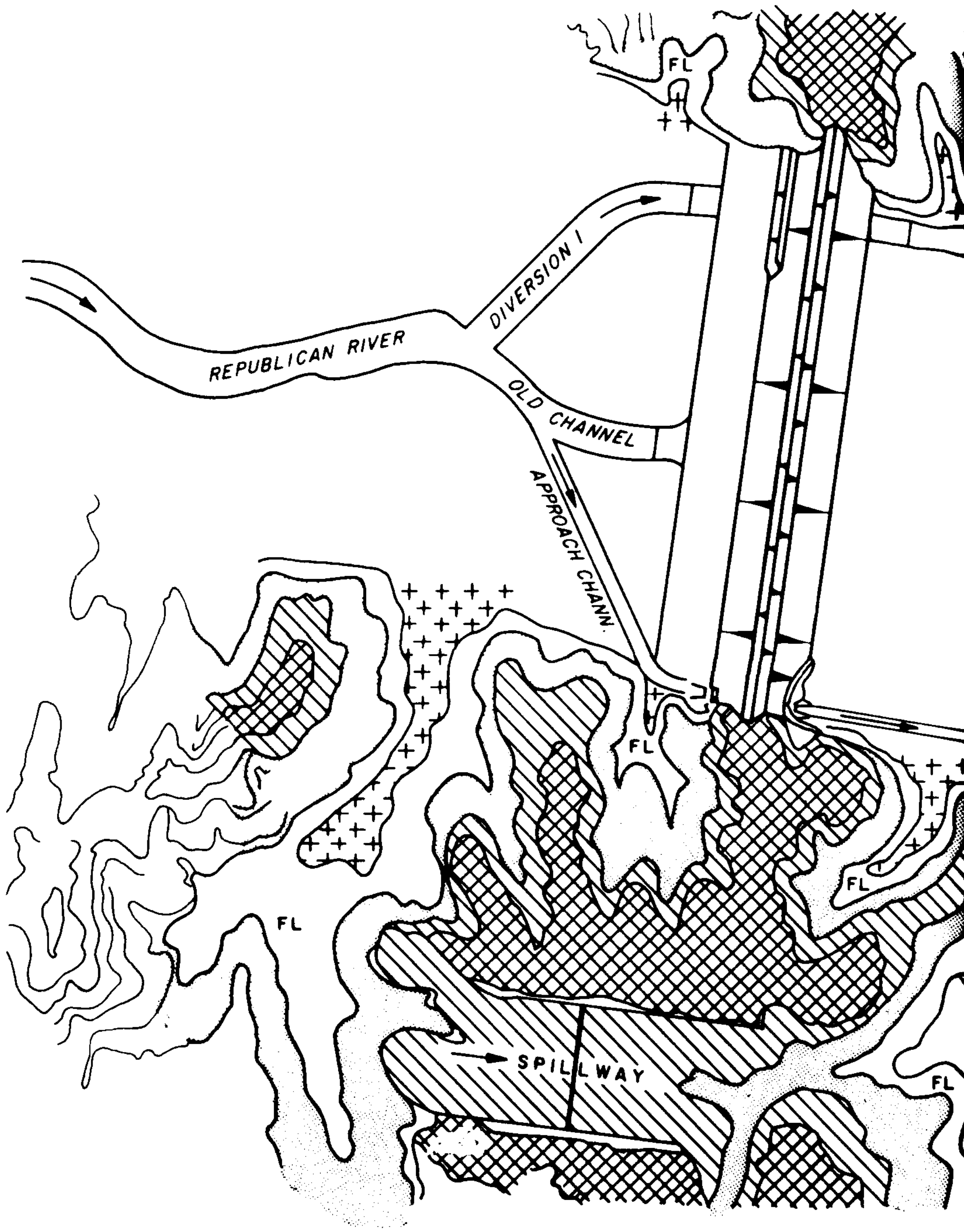
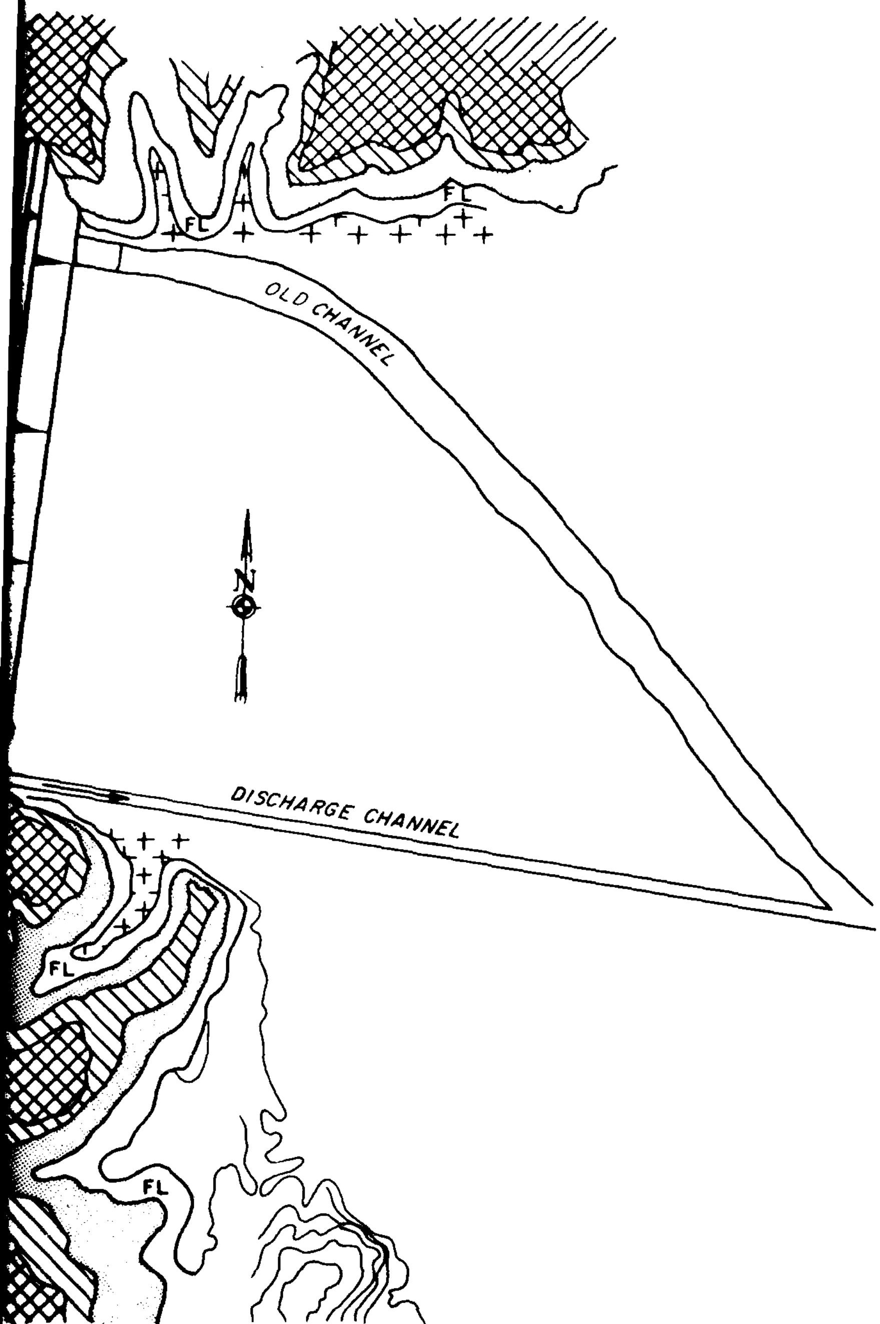

FL
DIVERSION I
REPUBLICAN RIVER
OLD CHANNEL
APPROACH CHANN.
FL
FL
FL
SPILLWAY
FL

FIGURE 3

LEGEND

- TOWANDA LS
- HOLMESVILLE SH
- FORT RILEY LS
- FLORENCE LS — FL
- BLUE SPRINGS SH



REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

GEOLOGIC MAP OF CONSTRUCTION AREA

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KANSAS CITY DISTRICT

FILE NO. B-1-1923

APRIL 1977

E 3

FIGURE 3

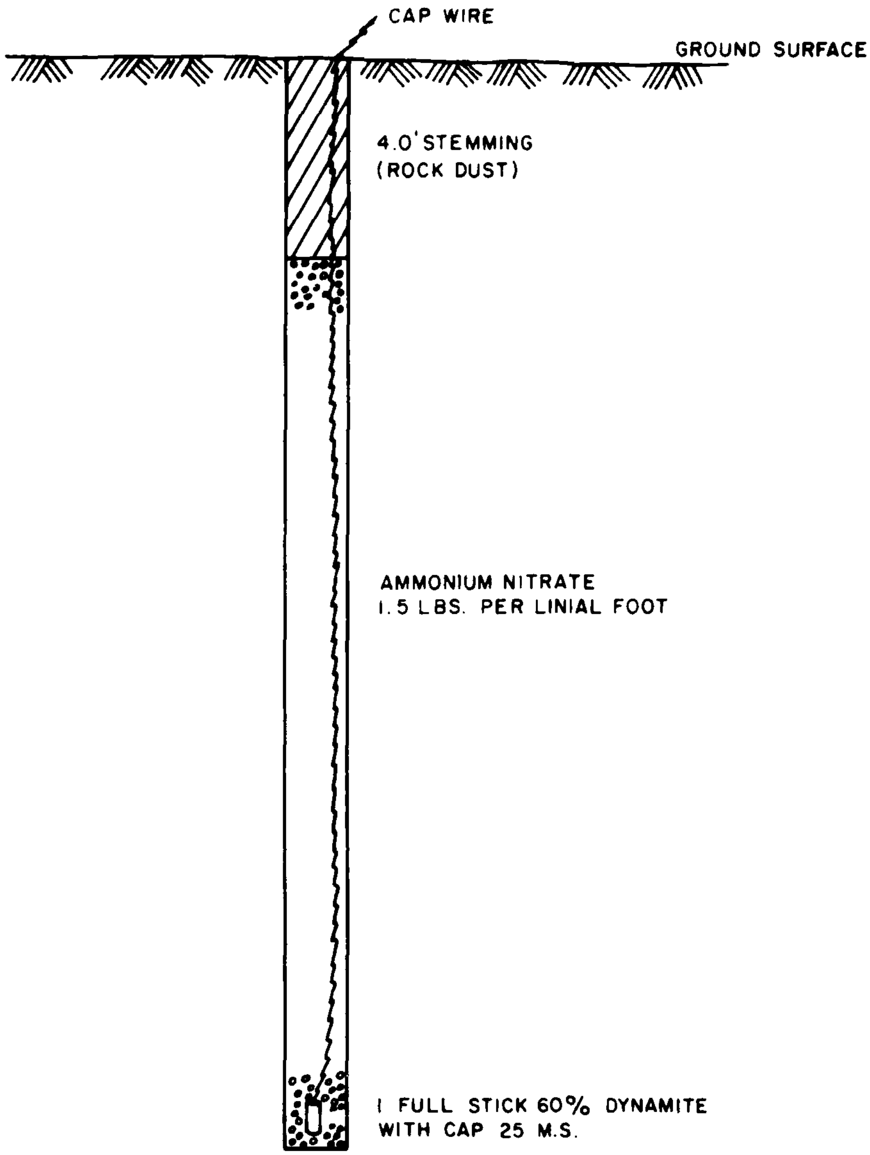

FIGURE 4

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

TYPICAL LOADING COLUMN
OUTLET WORKS EXCAVATION

In 1 sheet   Sheet No. 1   Not to scale

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KANSAS CITY DISTRICT

FILE NO. B-1-1924

APRIL 1977

SHOT RECORD

SHOT NO: 28
*DATE: 10-27-62
*TIME: 1730

*PROJECT: Milford Dam
*CONTRACTOR: Western Contracting Corporation SUB:
*PURPOSE OF BLAST: Outlet Works

DRILLING DATA

*LOCATION: Outlet Works *STA: 1+15 ds TO 4+70 ds
*RN: 0+25 L TO 0+25 R
SURFACE ELEV: 1168
BOTTOM ELEV: 1153
GEOL FMTN'S: Fort Riley zones A-B-C
VOL: L 240 X W 50 X H 15 = 6600 CY
*DRILL TYPE: Air Trac-Rotory DRILL ANGLE: V
*HOLE DIA: 31/2" 41/2" SLOPE (FREE FACE):
*NO OF HOLES: 146 *DEPTH 15 *PATTERN: 7 X 9' 9X12'

EXPLOSIVE DATA

	Total Amt	*Trade Name	*STN	*Size
1	1700 LBS	Dynamite	40 %	Standard
2	70 LBS	Dynamite	60 %	Standard
3	3150 LBS	Ammonium Nitrate		Bulk
4	LBS			

POWER FACTOR: 1 0.26 LB/CY 2 0.01 LB/CY 3 0.48 LB/CY 4 LB/CY
TOTAL: 0.75 LB/CY

DETONATORS:
*TYPE: Electric Delay 25MS *PRIMACORD? No

*PERIODS:	1	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	30	29	29	29	29										

*LOADING DIAGRAM:

4.0' Stemming

22# Ammonium Nitrate

1 Stick Dynamite

RESULTS

EXCAVATION METHOD: Electric power Marion Shovel w/ 7 1/2 cy dipper
QUANTITY OF ROCK PRODUCED:
*FRAGMENTATION: Poor; considerable oversize
PRE-SPLIT RESULTS:

COMMENTS Conditions very wet toward middle of shot, holes "rifled."

*FURNISHED BY CONTRACTOR
MRK Form 1065
28 April 61

SIGNED
INSPECTOR OR CONTRACTOR

FIGURE 5

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

SHOT RECORD

In 1 sheet Sheet No. 1 Not to scale

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. B-1-1925
APRIL 1977

FIGURE 5

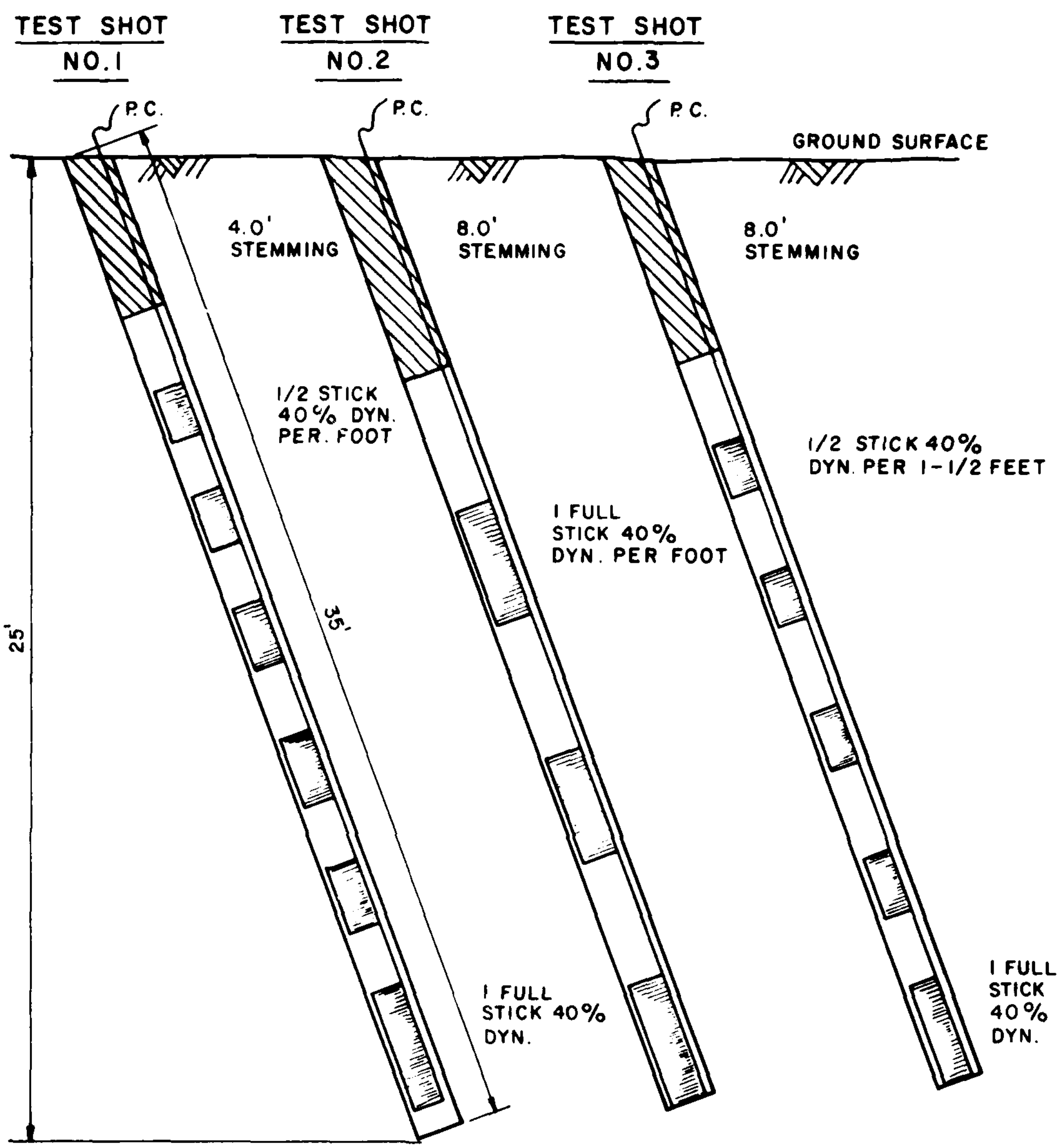

FIGURE 6

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

PRE-SPLIT TEST SHOTS

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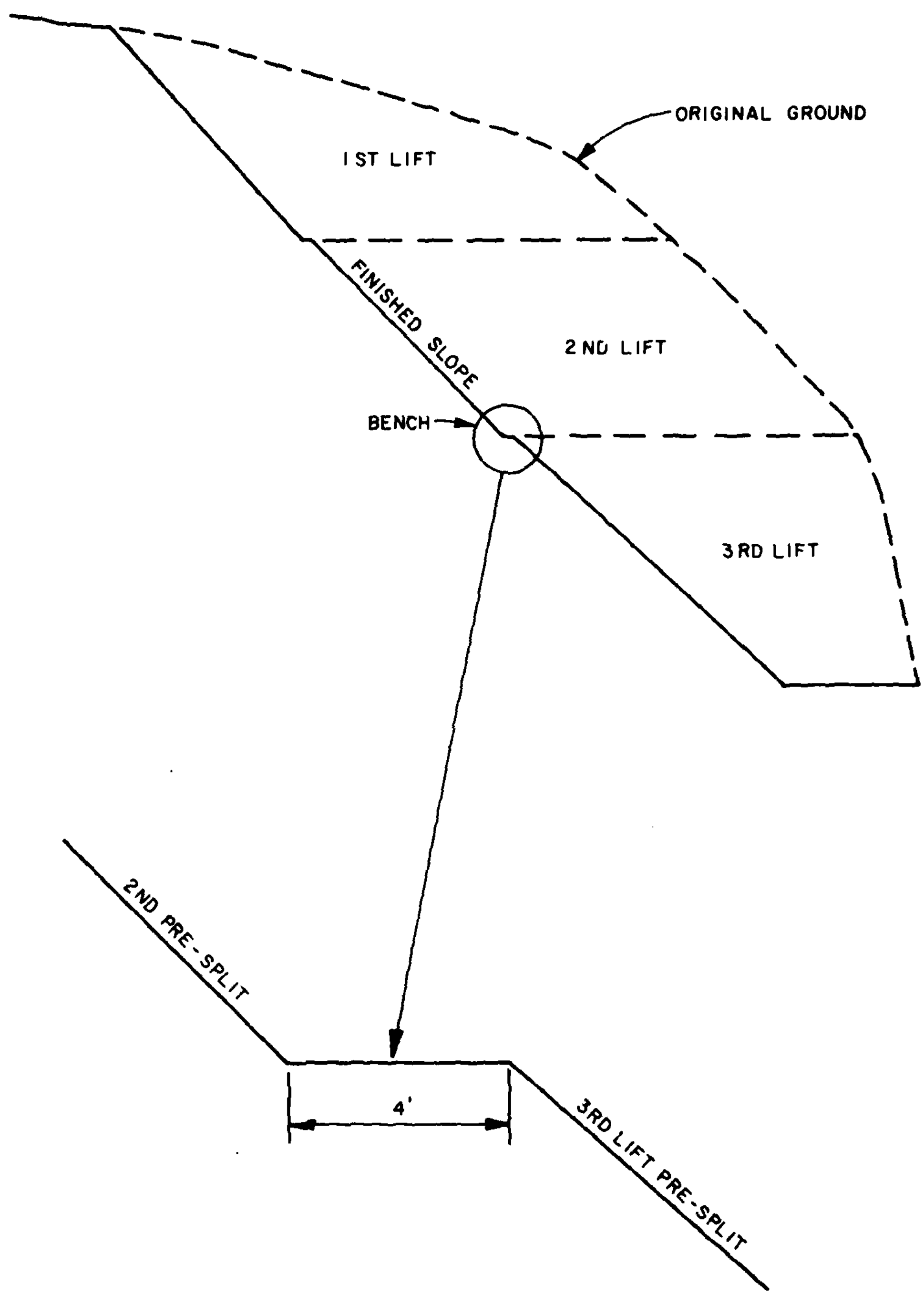
KANSAS CITY DISTRICT

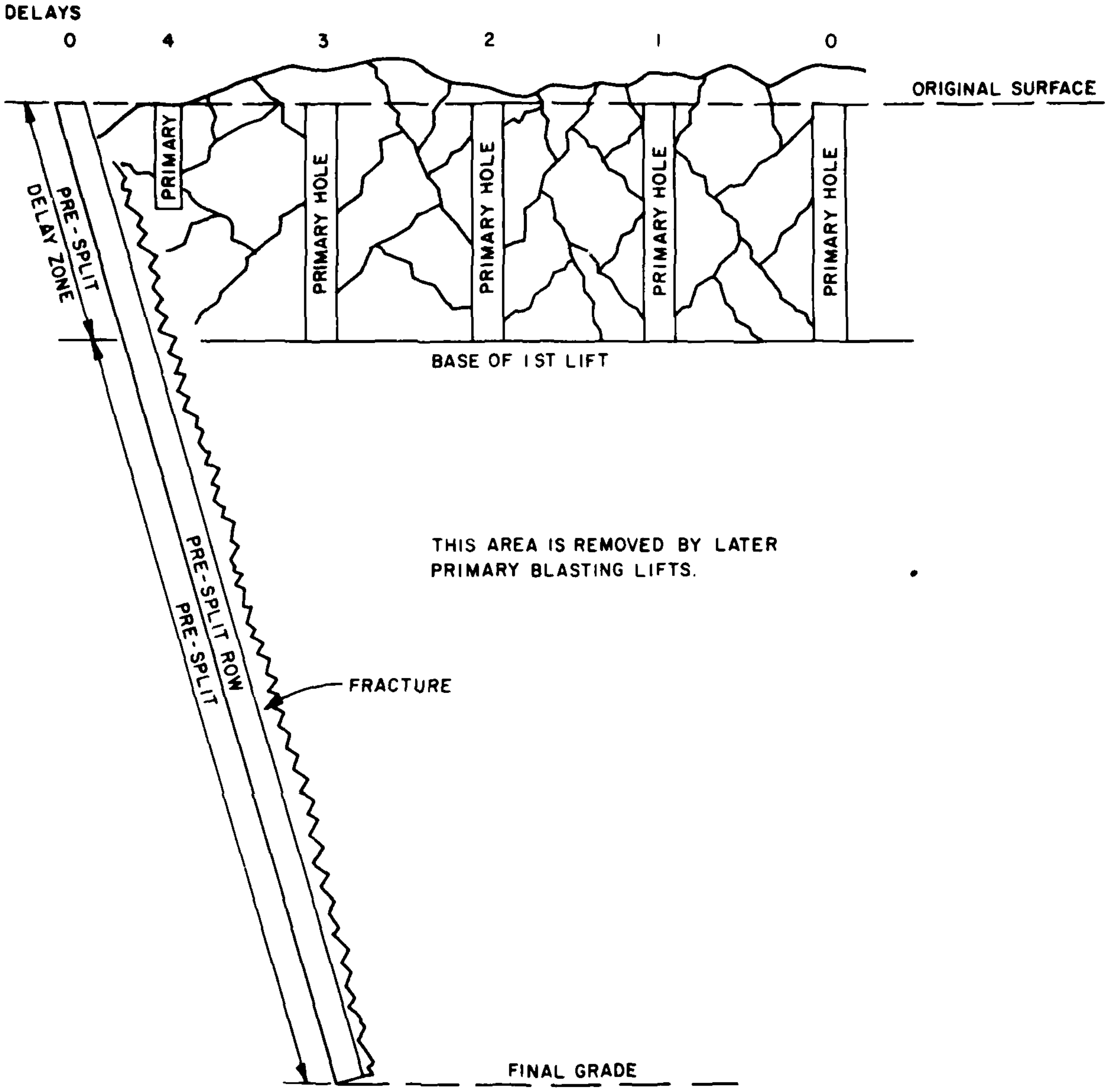
FILE NO. B-1-1926

APRIL 1977



TYPICAL BENCHES MARKING PRE-SPLIT LIFTS

FIGURE 7



PRE-SPLIT DELAY BLASTING

FIGURE 8

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT
TYPICAL BENCHES MARKING
WITH PRE-SPLIT LIFTS
PRE-SPLIT DELAY BLASTING

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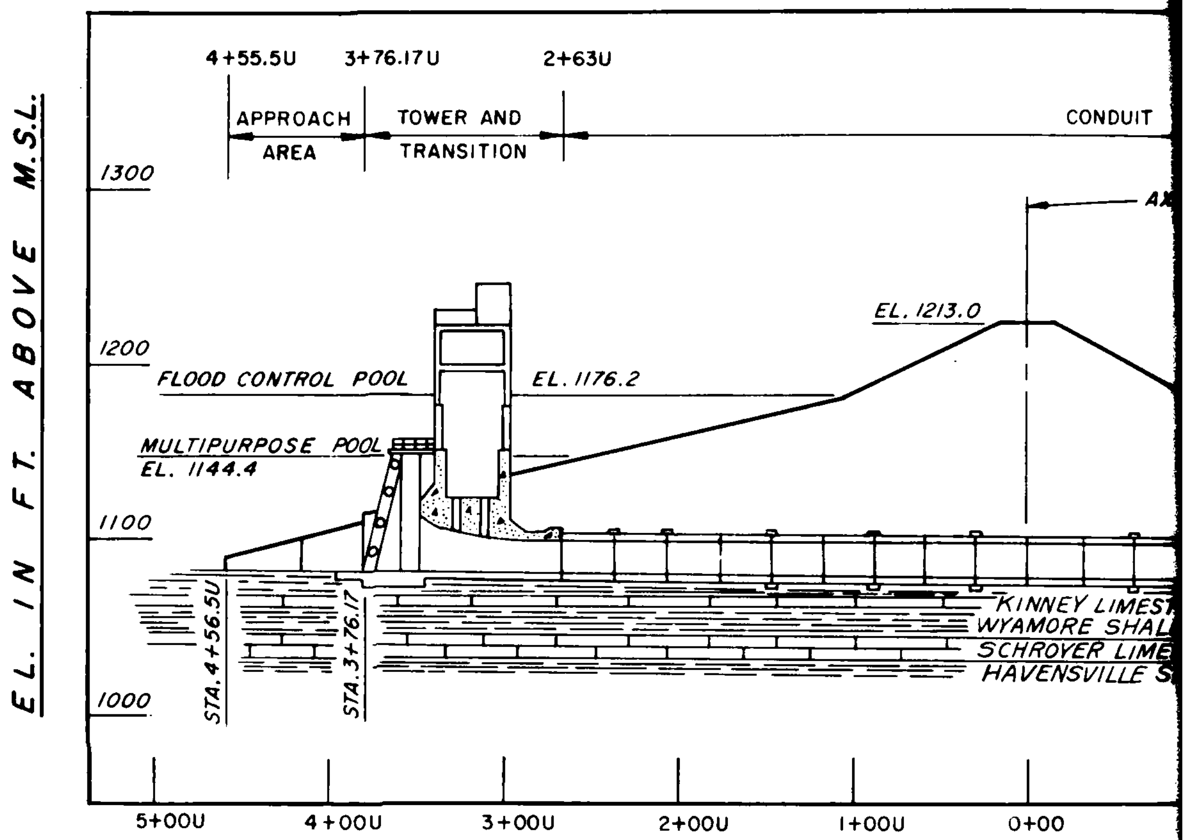
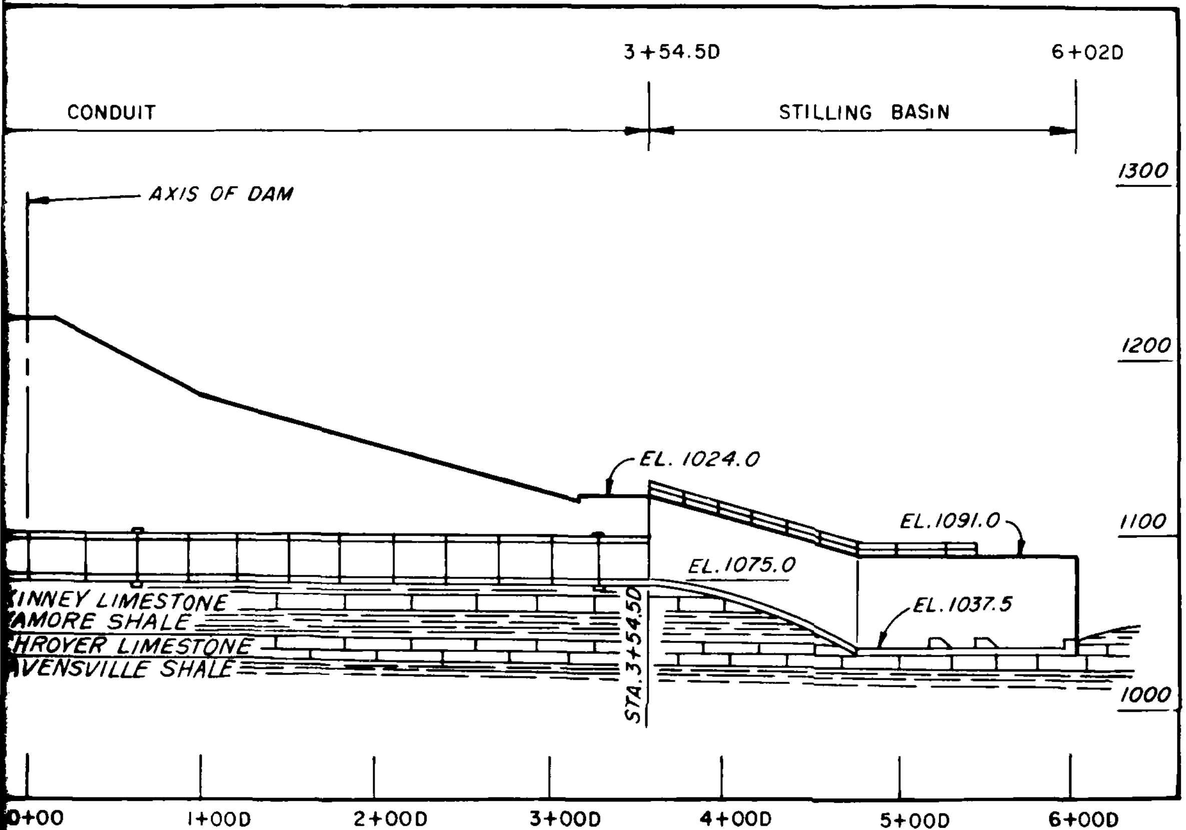
KANSAS CITY DISTRICT
FILE NO. B-1-1927
APRIL 1977

FIGURE 7



Scale : I"=

FIGURE



Scale : 1" = 100'

FIGURE 9

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

OUTLET WORKS SECTION

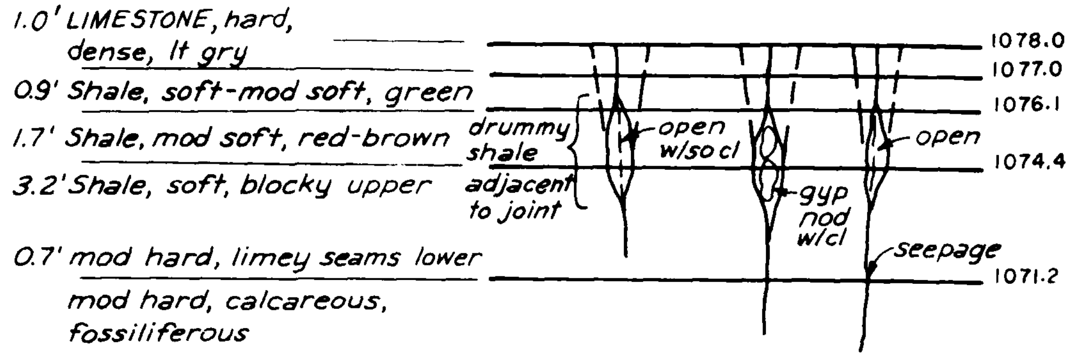
In 1 sheet Sheet No. 1 Scale: as shown

CORPS OF ENGINEERS U. S. ARMY

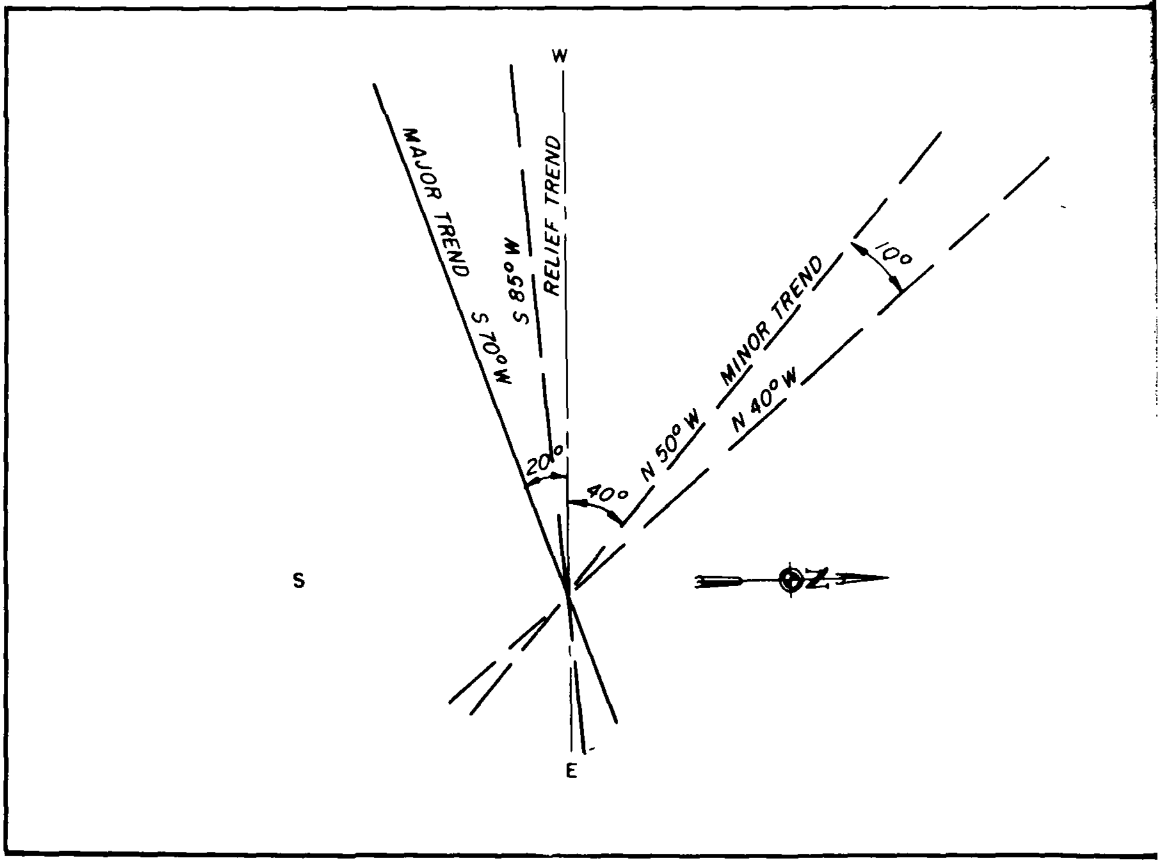
KANSAS CITY DISTRICT

FILE NO. B-1-1928

APRIL 1977

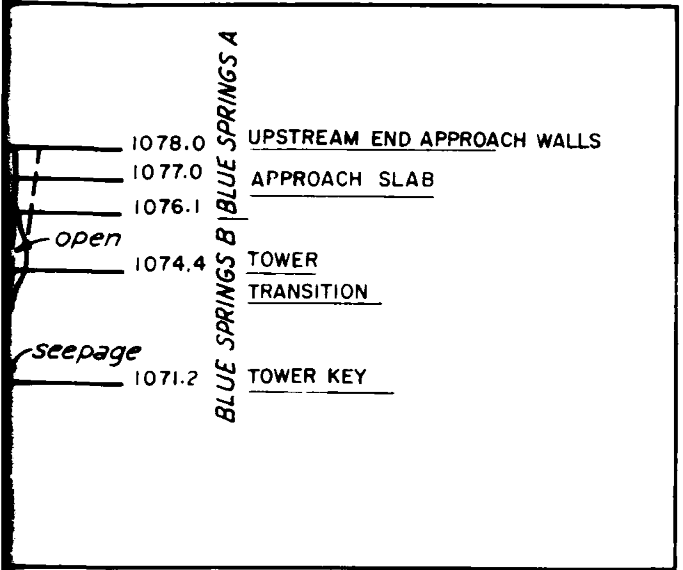


JOINT CONDITIONS



JOINT SYSTEM

FIGURE 10



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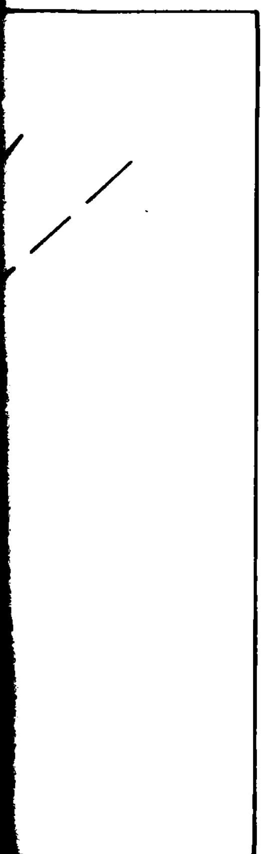

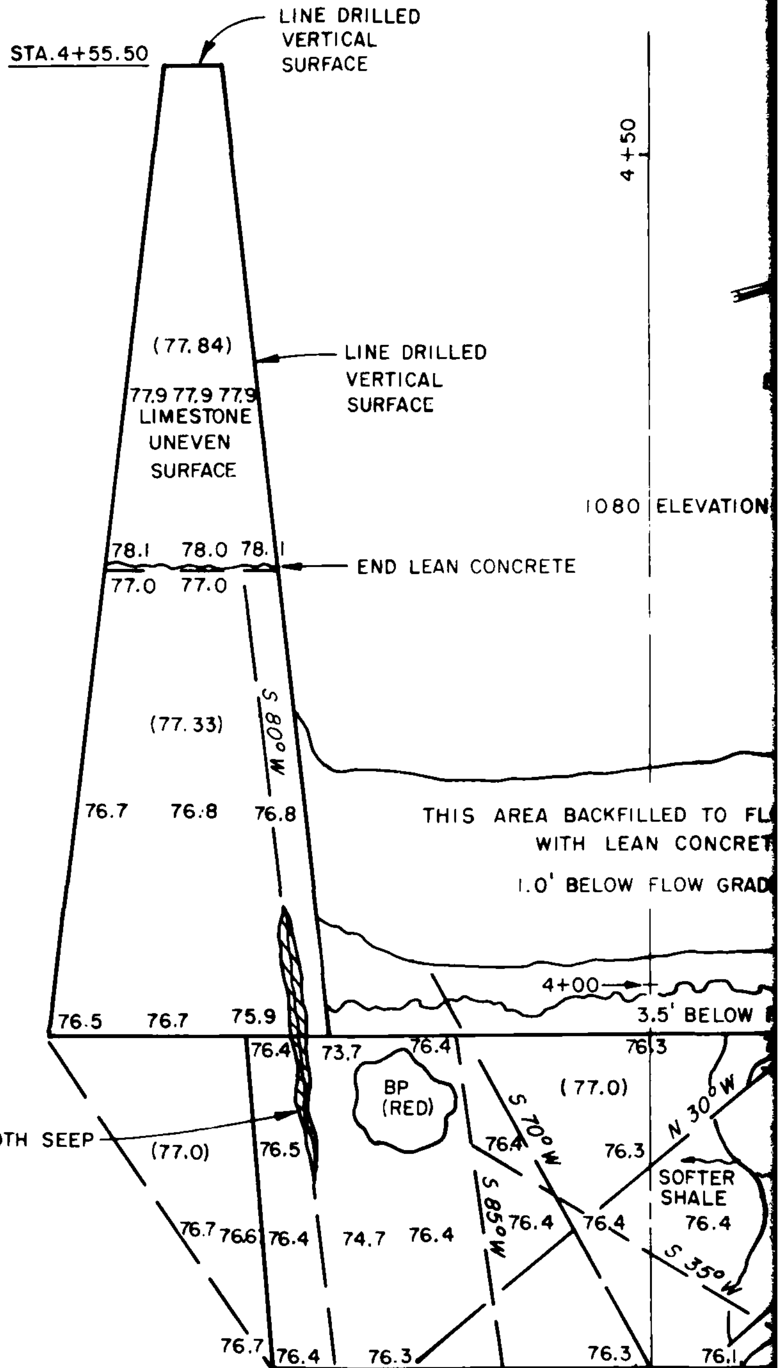

NOTE:
THEORETICAL ELEVATIONS IN

APPROACH AREA

FIGUR

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

JOINT SYSTEM AND CONDITIONS APPROACH AREA FOUNDATIONS

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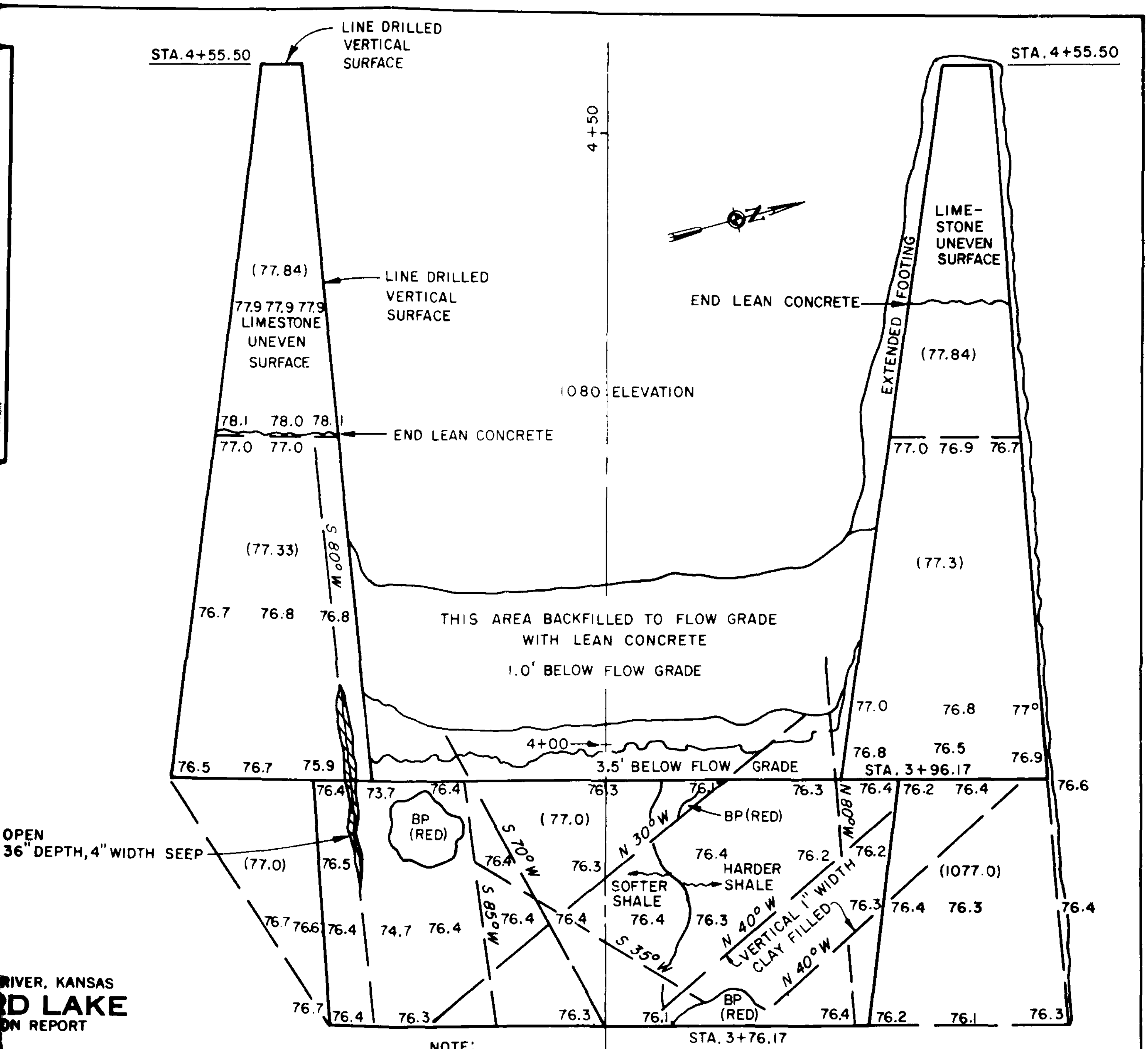
KANSAS CITY DISTRICT

FILE NO. B-1-1929

APRIL 1977



NOTE:
THEORETICAL ELEVATIONS IN PARENTHESES.

APPROACH AREA FOUNDATIONS

FIGURE 11

RIVER, KANSAS
D LAKE
ON REPORT

AND CONDITIONS
A FOUNDATIONS

O. I

Not to scale

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Y DISTRICT

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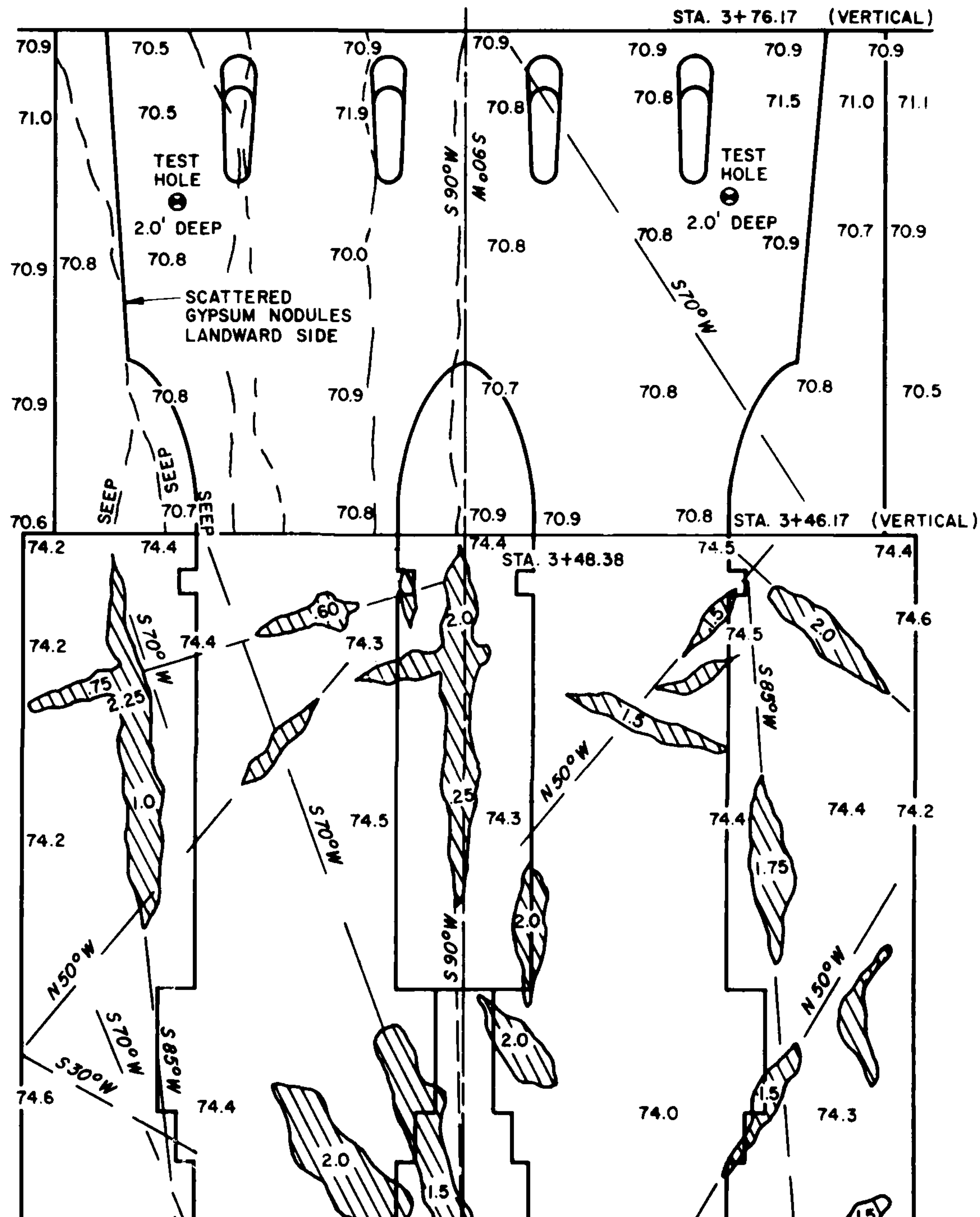
1977

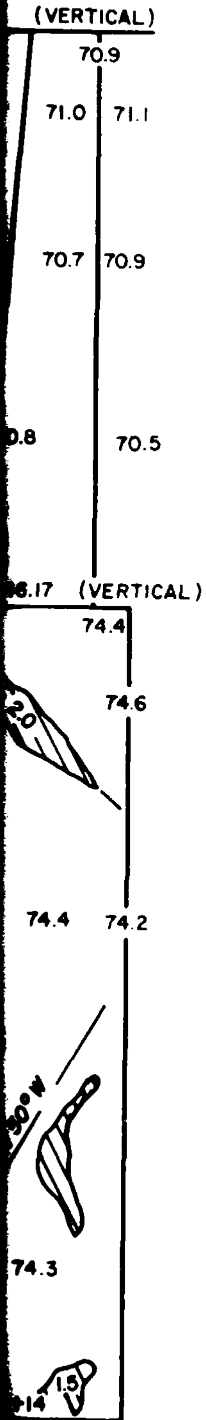
FIGURE 10 & 11

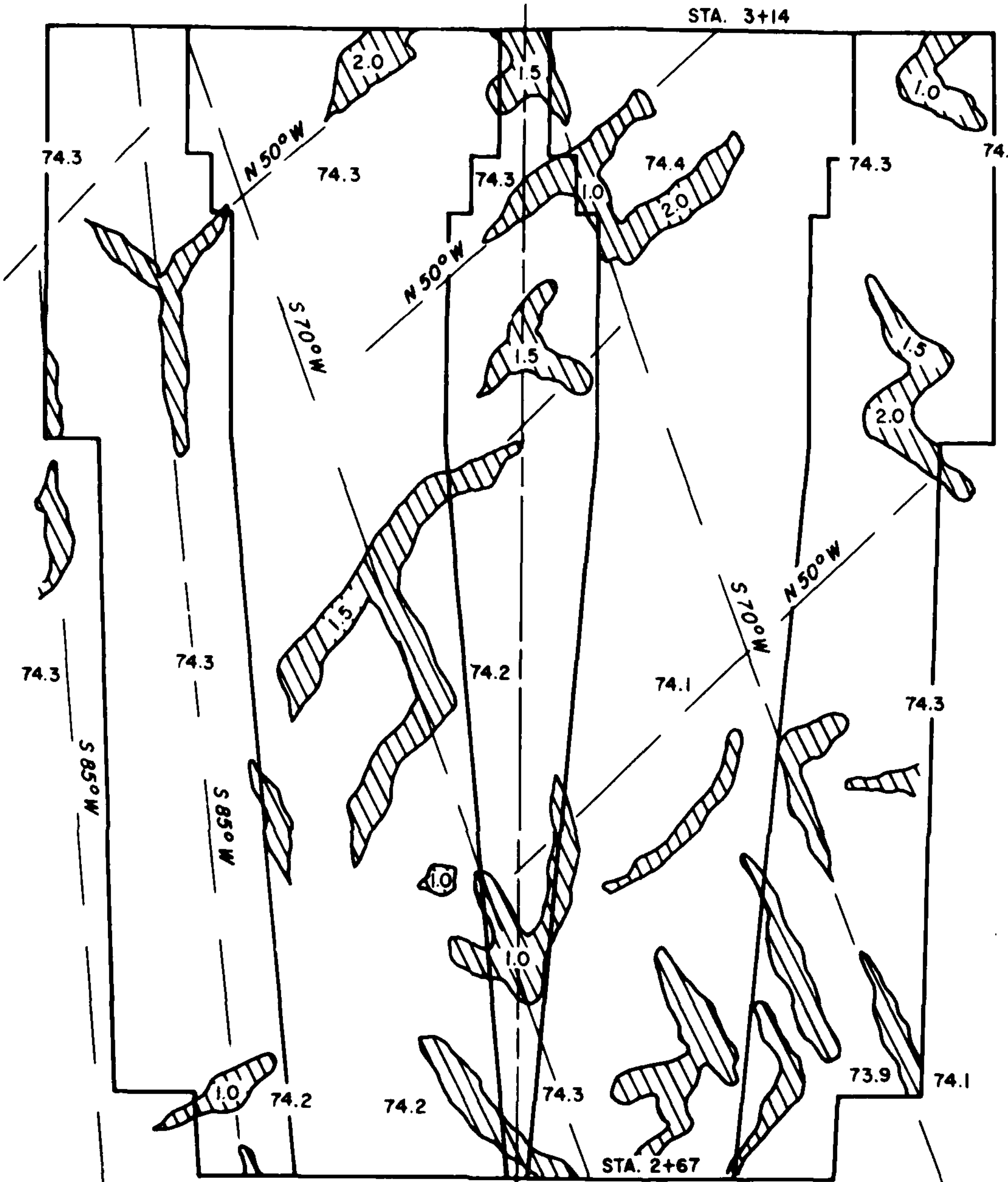
2 1 3



TOWER FOUNDATIONS

FIGURE 12





TRANSITION FOUNDATIONS

FIGURE 13

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

TOWER AND TRANSITION FOUNDATIONS

In 1 sheet | Sheet No. 1 | Not to sca

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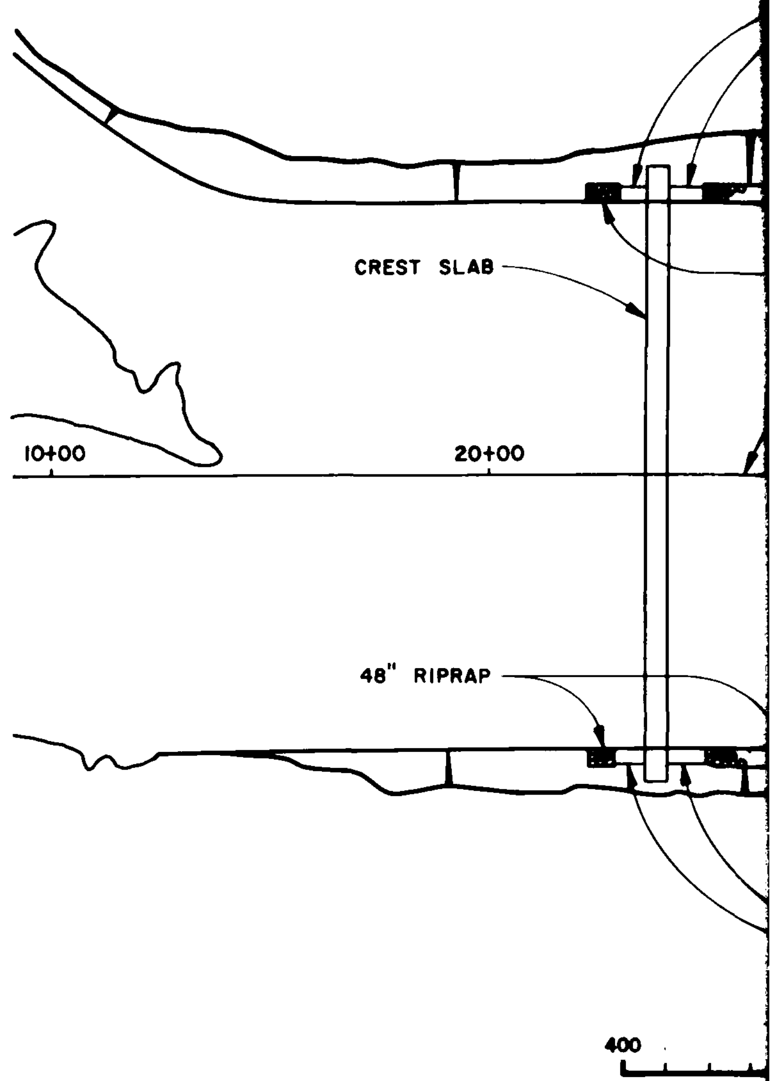
KANSAS CITY DISTRICT

FILE NO. B-1-1930

APRIL 1977

FIGURE 12 B

2



CREST SLAB
10+00
20+00
48" RIPRAP
400

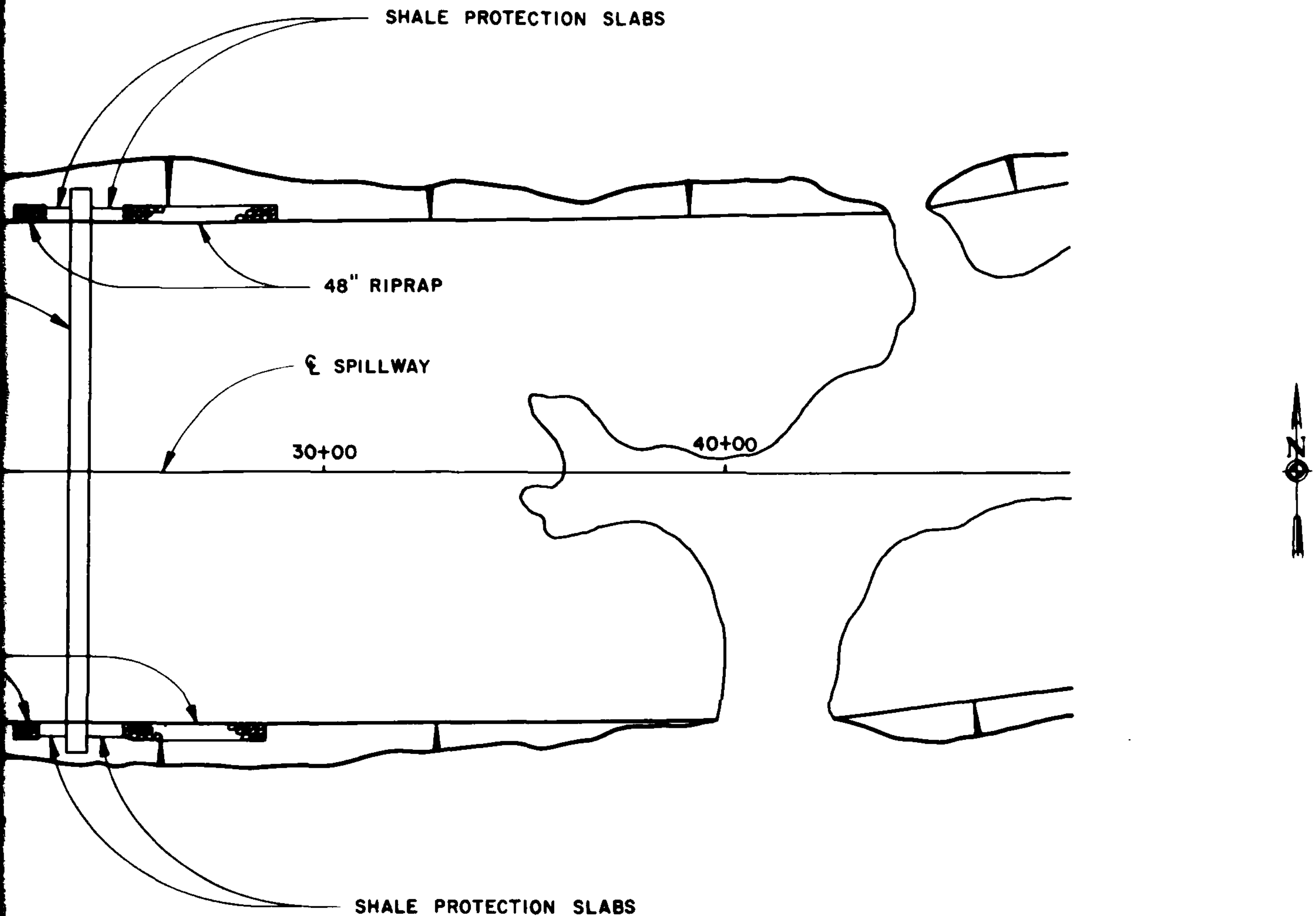


FIGURE 14

400 0 400 800
SCALE IN FEET

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

SPILLWAY PLAN

In 1 sheet | Sheet No. 1 | Scale: as show

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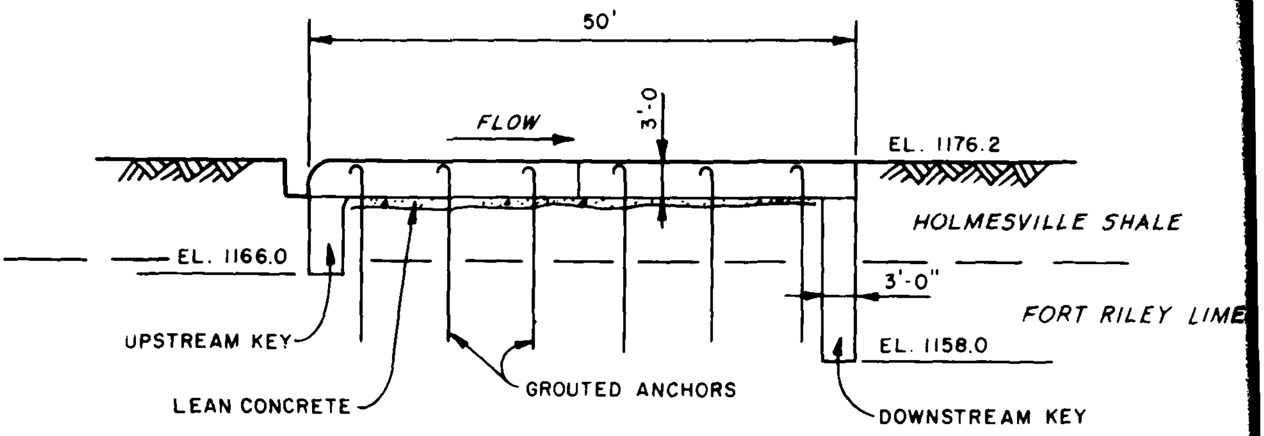
KANSAS CITY DISTRICT

FILE NO. B-1-1931
APRIL 1977

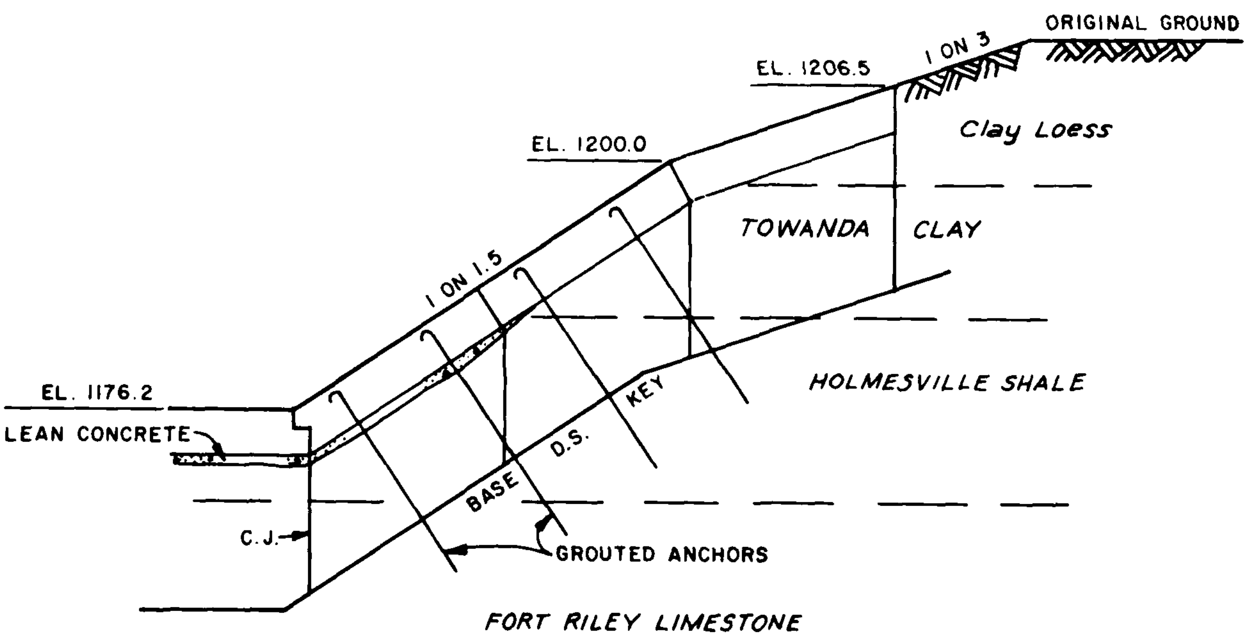
FIGURE

1 2



TYPICAL SECTION

SPILLWAY SILL



SLOPE SECTION

SPILLWAY SILL

FIGURE 15

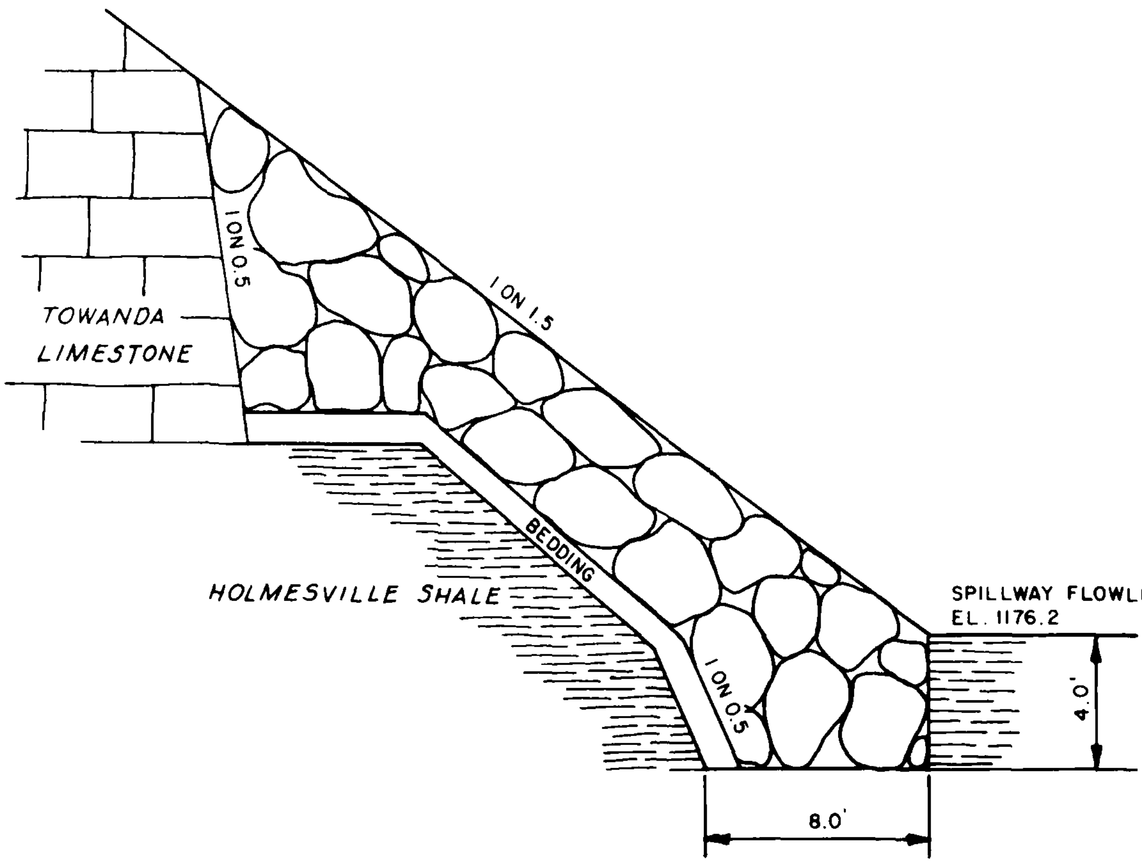
E SHALE

T RILEY LIMESTONE

Y

IGINAL GROUND

SS



SPILLWAY 48" RIPRAP

FIGURE 16

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

SPILLWAY SILL AND
SPILLWAY RIPRAP

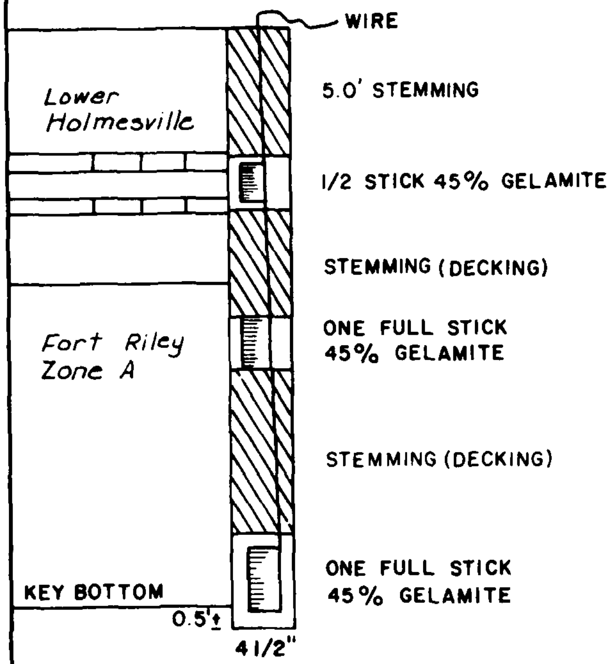
In 1 sheet | Sheet No. 1 | Not to scale

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

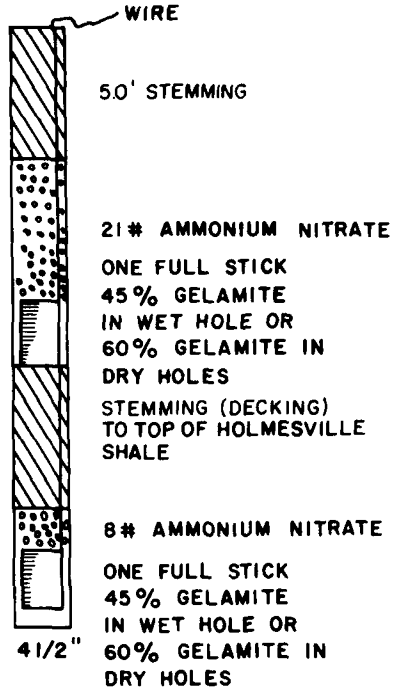
FILE NO. B-1-1932

APRIL 1977

LOADING COLUMN DS KEY



GENERAL EXCAVATION DECK LOADING



TYPICAL LOADING COLUMN

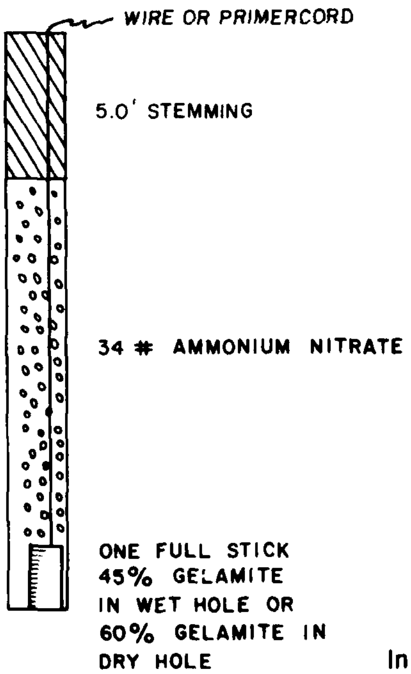


FIGURE 17

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

LOADING COLUMNS WITH EXPLOSIVES FOR EXCAVATION

In 1 sheet Sheet No. 1 Not to scale

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1933

APRIL 1977

FIGURE 17

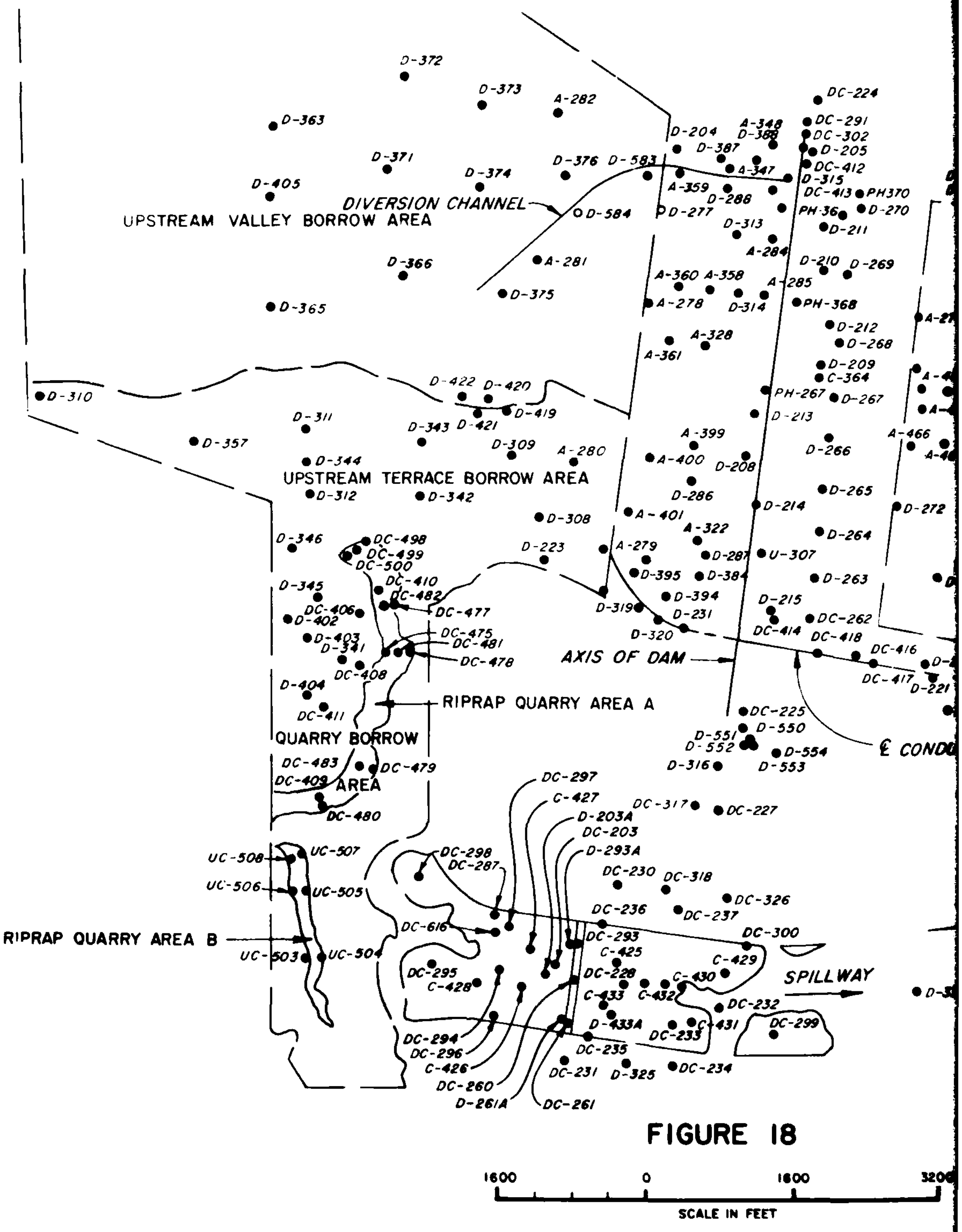
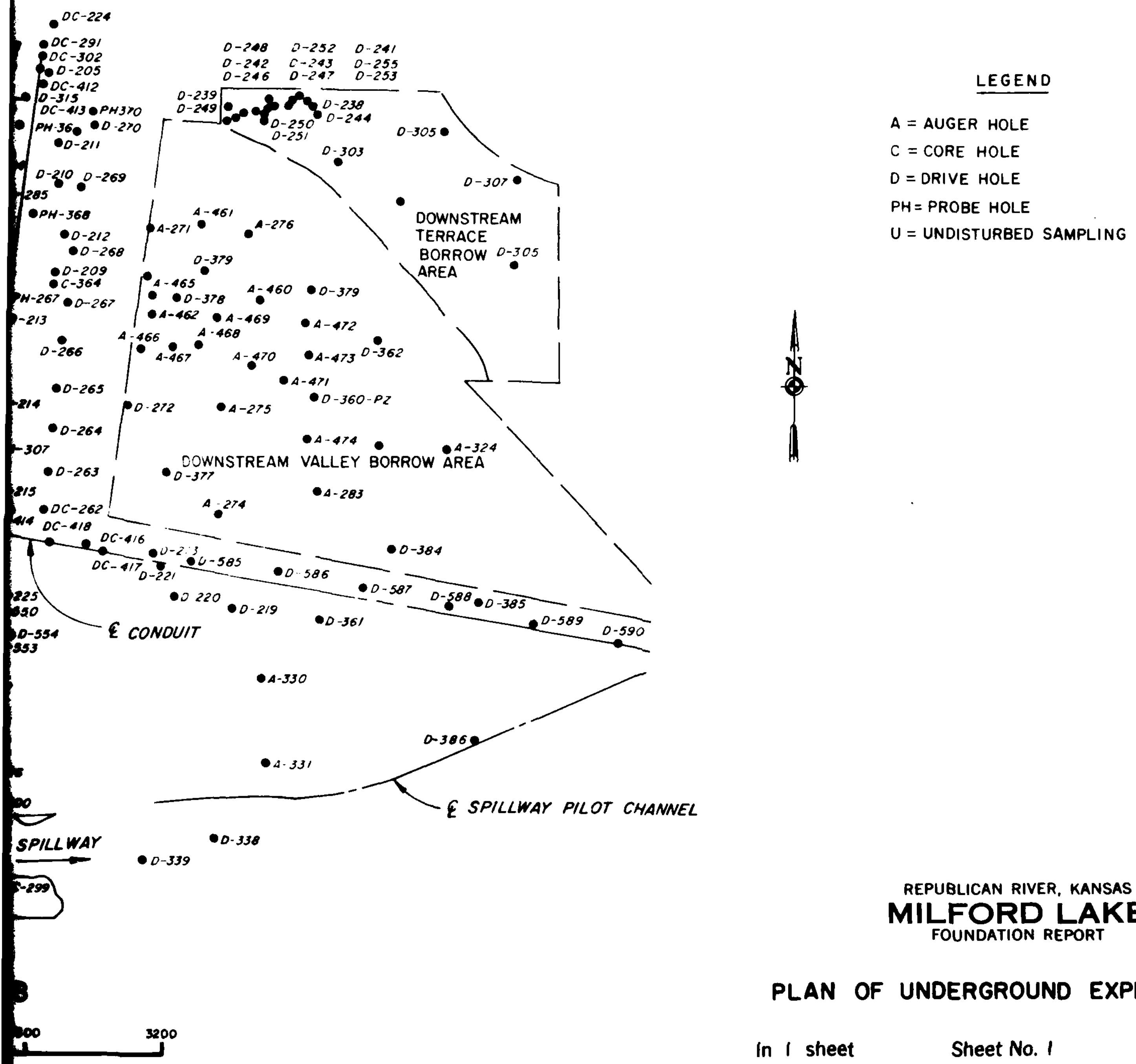

UPSTREAM VALLEY BORROW AREA
DIVERSION CHANNEL
UPSTREAM TERRACE BORROW AREA
AXIS OF DAM
RIPRAP QUARRY AREA A
QUARRY BORROW AREA
RIPRAP QUARRY AREA B
SPILLWAY
℄ COND
1600
0
1600
3200
SCALE IN FEET

FIGURE 18



3200

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

PLAN OF UNDERGROUND EXPLORATIONS

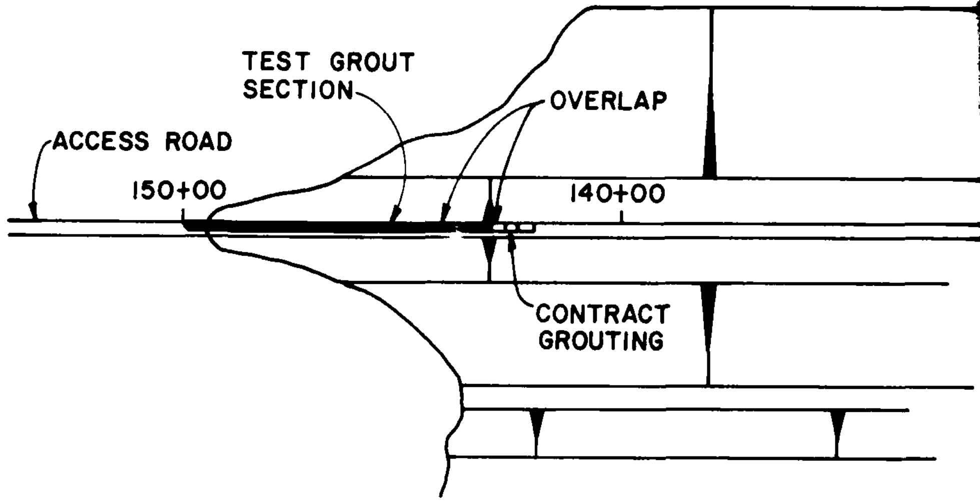
In 1 sheet Sheet No. 1 Scale as show

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

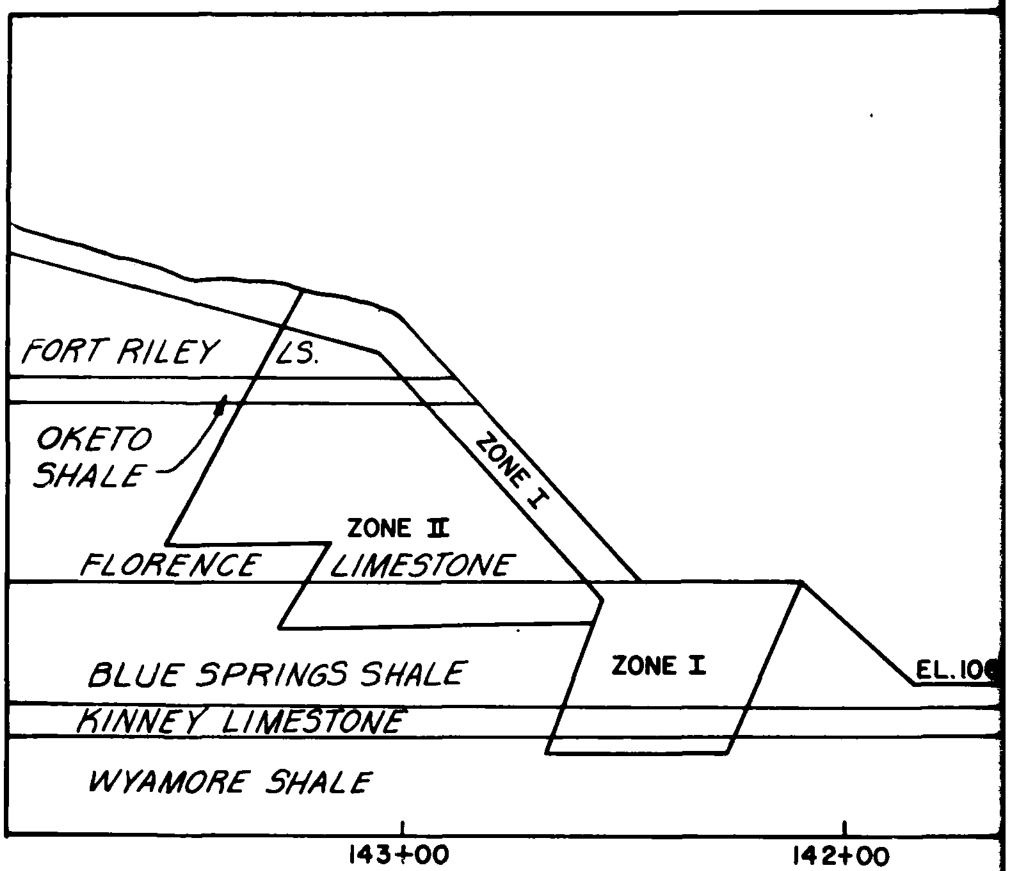
FILE NO. B-1-1934

APRIL 1977

FIGURE 2

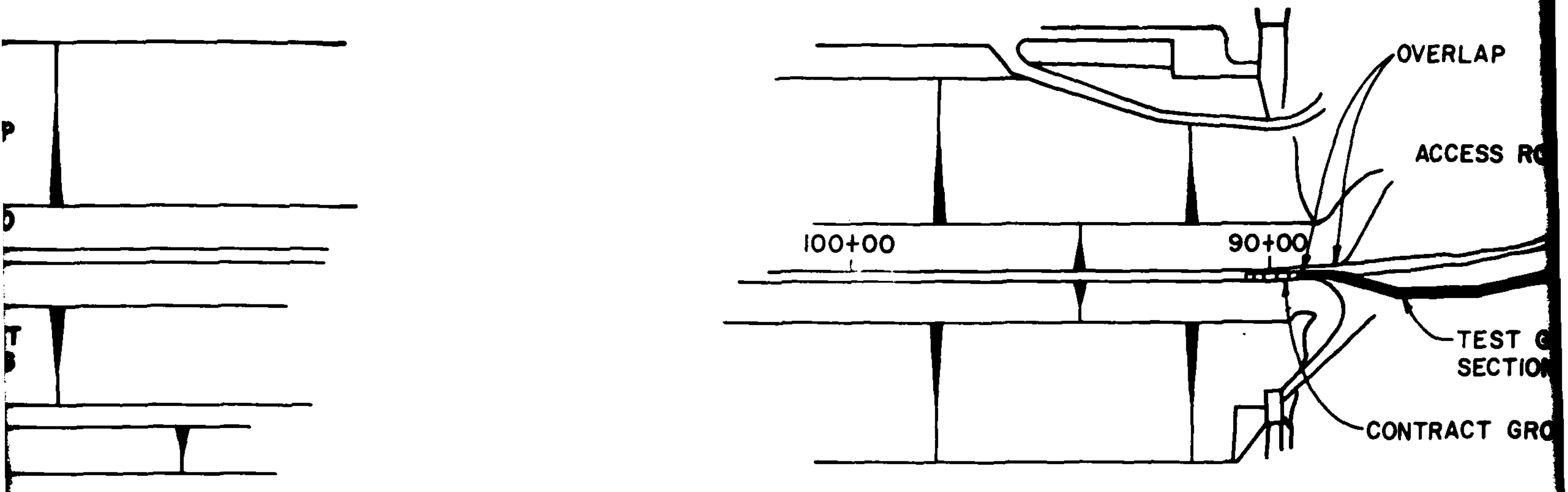


LEFT ABUTMENT GROUT CURTAIN



LEFT ABUTMENT GROUT CURTAIN

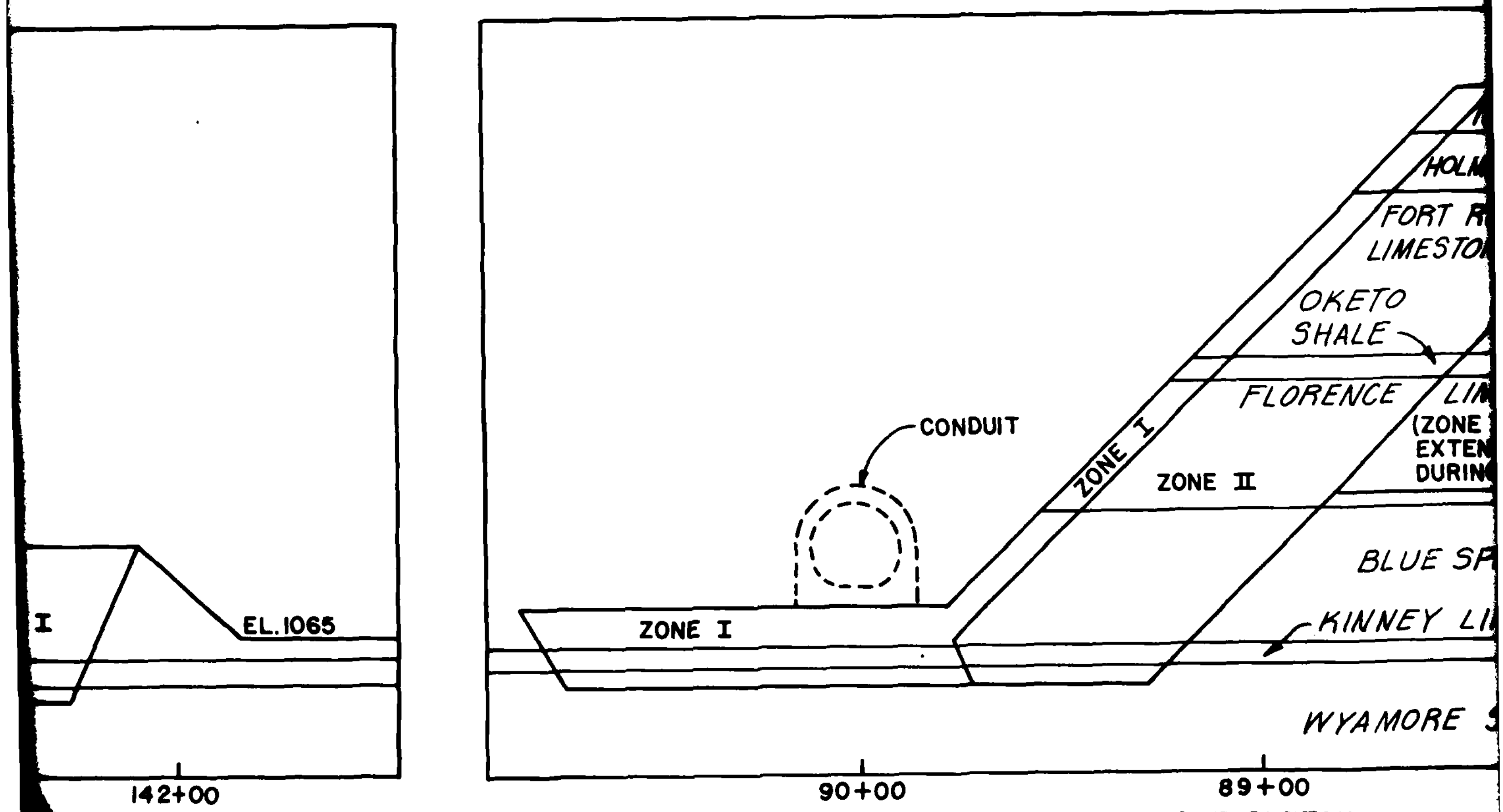
400



CURTAIN

RIGHT ABUTMENT GROUT CURTAIN

FIGURE 19



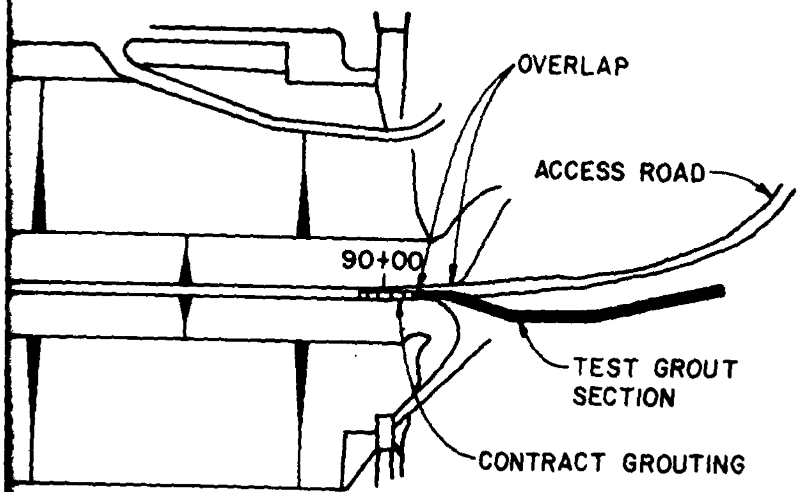
URTAIN

RIGHT ABUTMENT GROUT CURTAIN

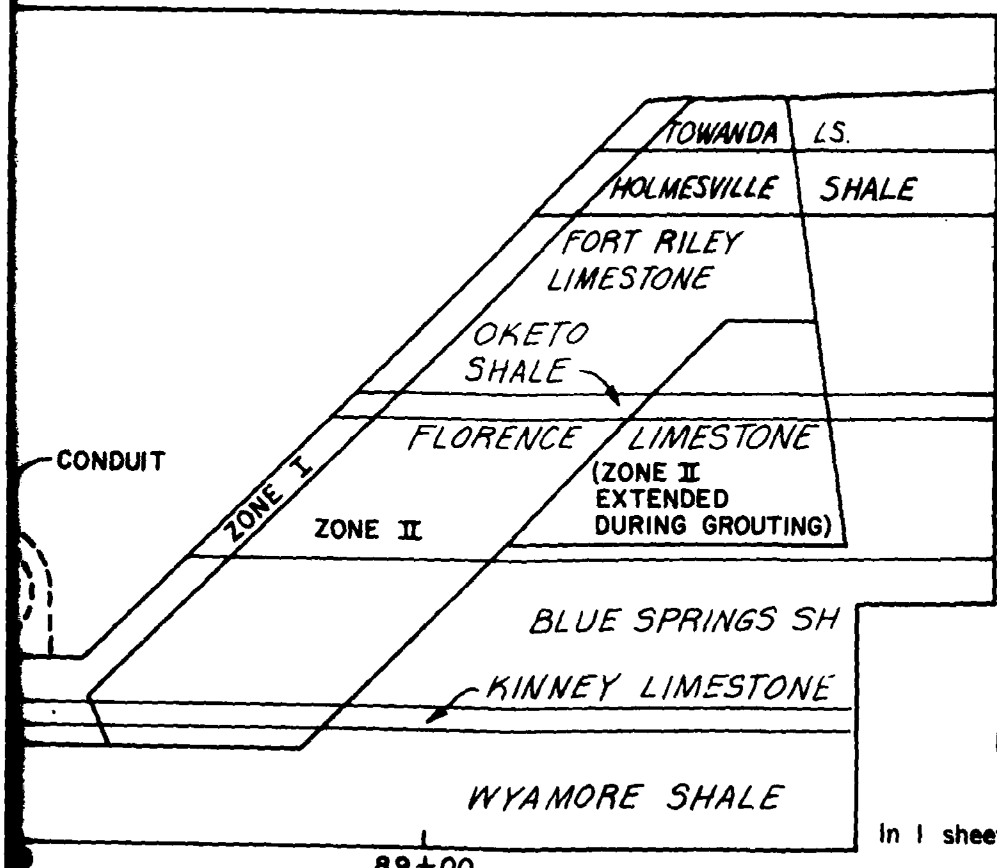
FIGURE 20

2

1



RIGHT ABUTMENT GROUT CURTAIN



HT ABUTMENT GROUT CURTAIN

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

LEFT AND RIGHT ABUTMENT GROUT CURTAINS

(LOOKING DOWNSTREAM)

In 1 sheet | Sheet No. 1 | Scale: as shown

CORPS OF ENGINEERS U. S. ARMY

KANSAS CITY DISTRICT

FILE NO. B-1-1935

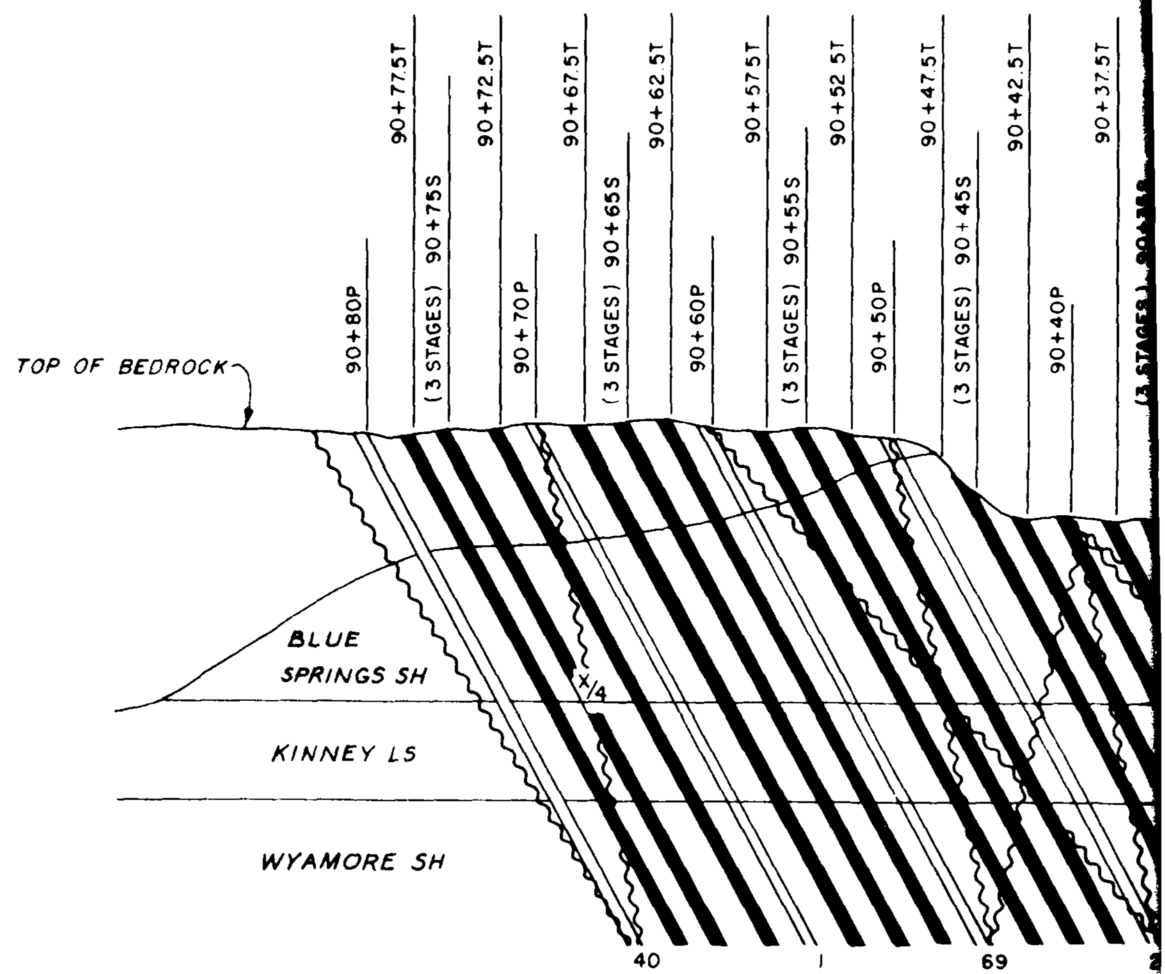
APRIL 1977

2

FIGURE 19 & 20

1

3



LEGEND

NO PRESSURE TEST — X

PRESSURE TEST 28 GPM / 116 BAGS PLACED — 28/116

OPEN ZONE

TIGHT

PRIMARY COMMUNICATION

SECONDARY COMMUNICATION

NOTE:
GROUT FIGURES @ BOTTOM OF HOLE = TAKE DEPTH UNKNOWN.

/

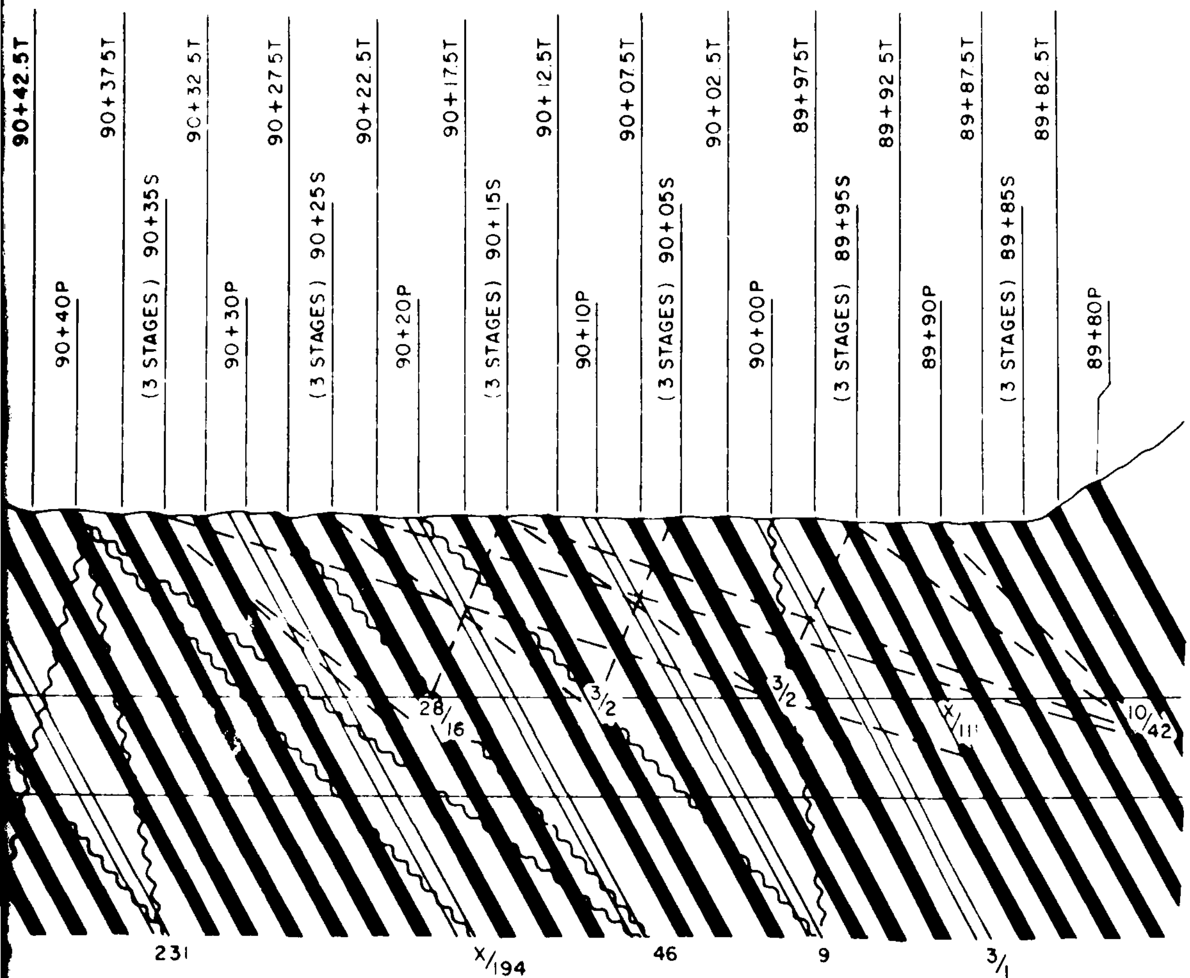


FIGURE 21

SECTION I

11	PRIMARY	308.8'	591	SACKS
10	SECONDARY	298.3'	177	SACKS
20	TERTIARY	572.9'	0	SACKS

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

GROUT LINE
RIGHT ABUTMENT
SECTION I

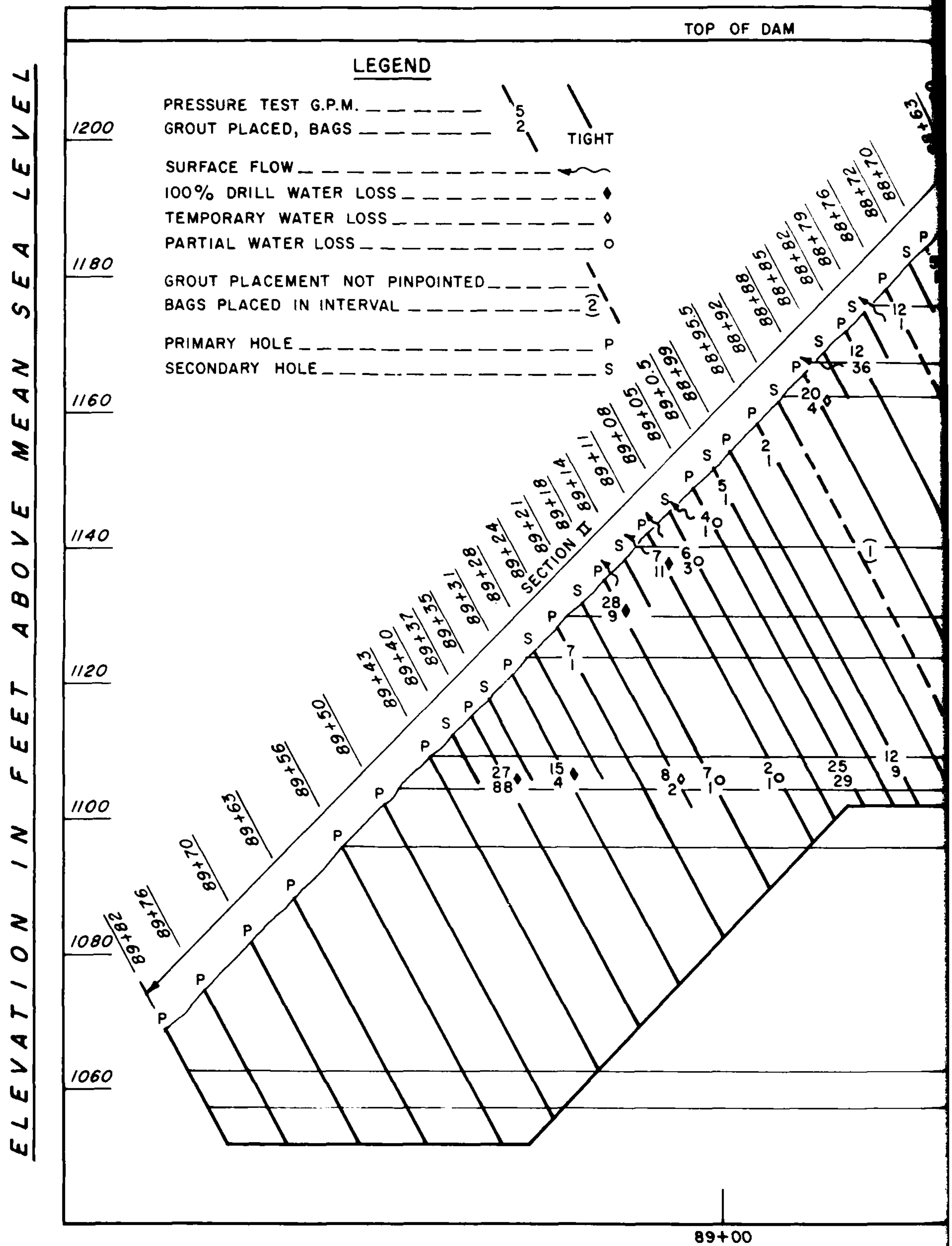
In 1 sheet Sheet No. 1 Not to scal

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1936

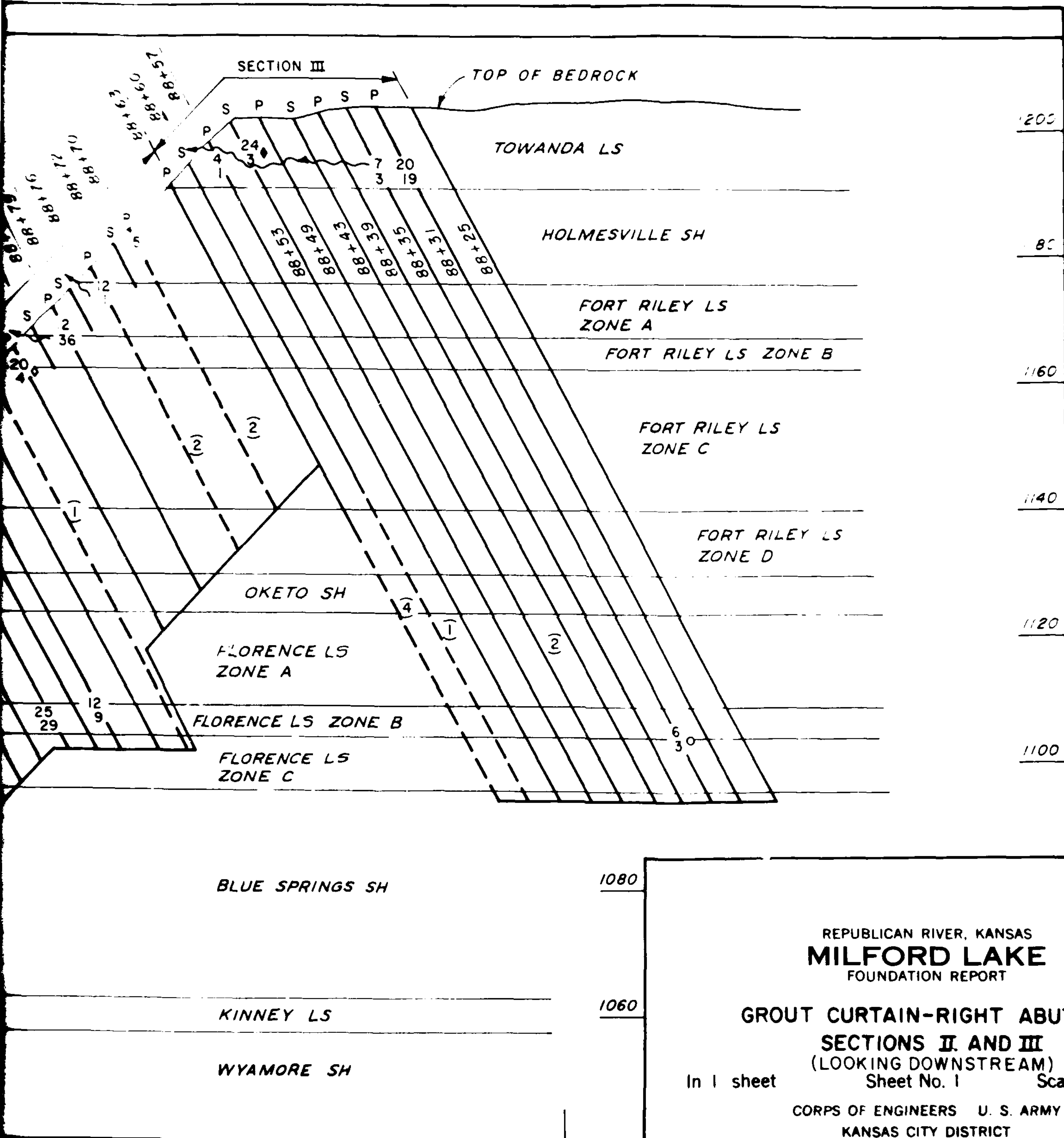
APRIL 1977

(LOOKING DOWNSTREAM)



SECTION II

19 PRIMARY	903.6'	201 SACKS
11 SECONDARY	283.8'	7 SACKS



REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

GROUT CURTAIN-RIGHT ABUTMENT SECTIONS II AND III

(LOOKING DOWNSTREAM)

In 1 sheet　　Sheet No. 1　　Scale: as shown

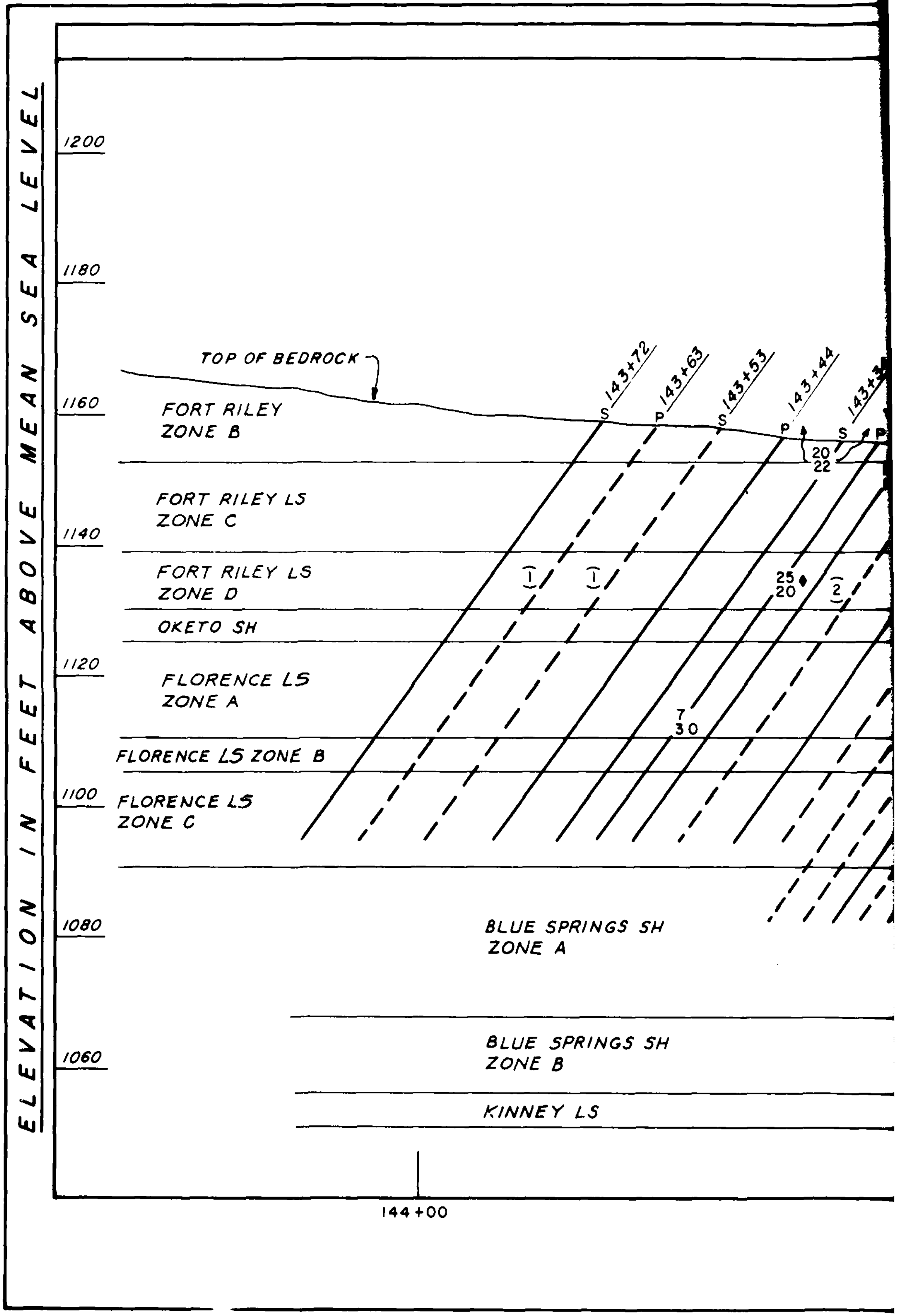
CORPS OF ENGINEERS　U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1937

APRIL 1977

FIGURE 22

SECTION III		
5 PRIMARY	559.6'	7 SACKS
4 SECONDARY	483'	7 SACKS



ELEVATION IN FEET ABOVE MEAN SEA LEVEL
1200
1180
1160
1140
1120
1100
1080
1060
TOP OF BEDROCK
143+72
143+63
143+53
143+44
FORT RILEY
ZONE B
20
22
FORT RILEY LS
ZONE C
FORT RILEY LS
ZONE D
25
20
OKETO SH
FLORENCE LS
ZONE A
7
30
FLORENCE LS ZONE B
FLORENCE LS
ZONE C
BLUE SPRINGS SH
ZONE A
BLUE SPRINGS SH
ZONE B
KINNEY LS
144+00

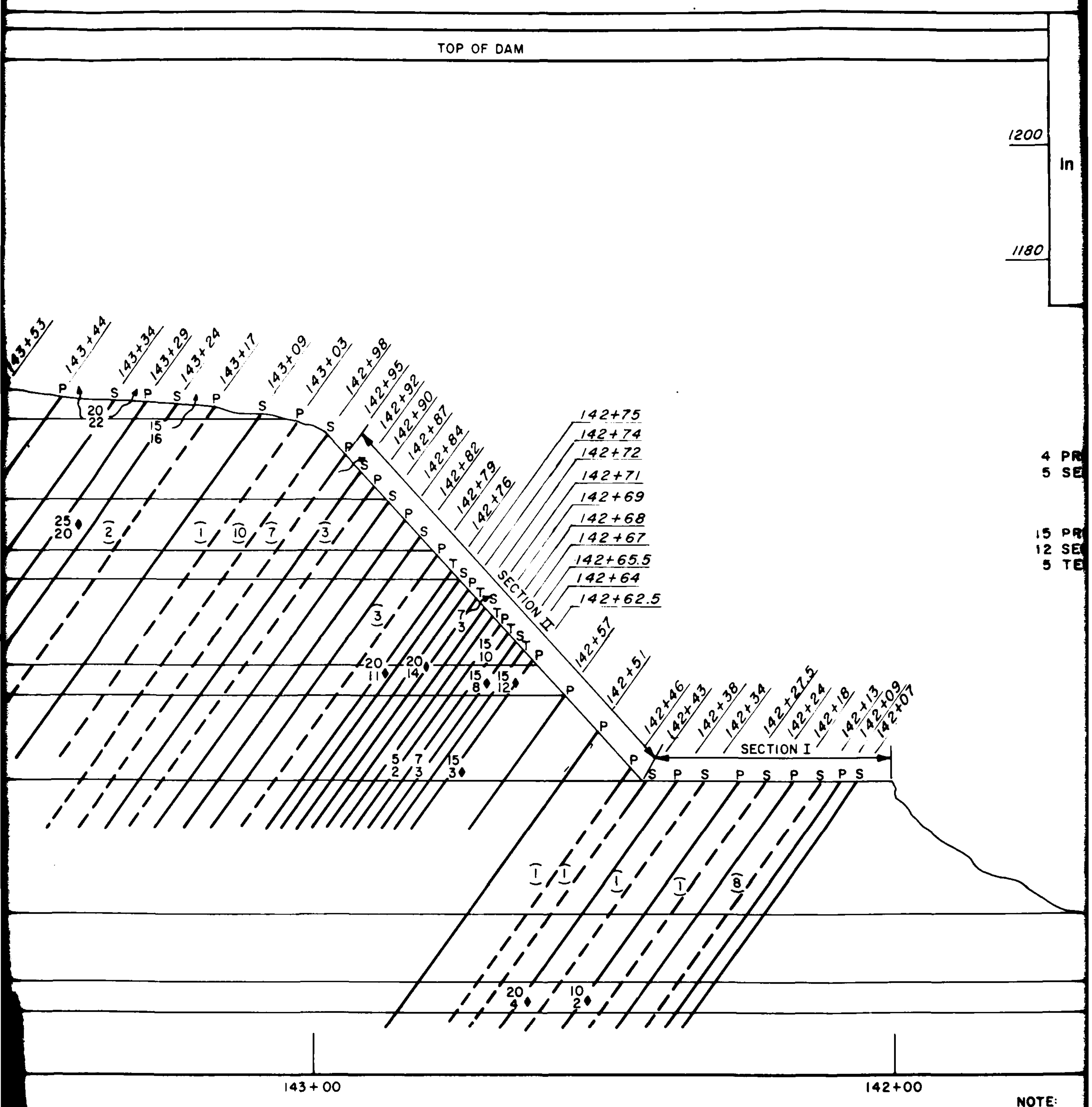

TOP OF DAM
1200
1180
In
143+53
143+44
143+34
143+29
143+24
143+17
143+09
143+03
142+98
142+95
142+92
142+90
142+87
142+84
142+82
142+79
142+76
142+75
142+74
142+72
142+71
142+69
142+68
142+67
142+65.5
142+64
142+62.5
142+57
142+51
142+46
142+43
142+38
142+34
142+27.5
142+24
142+18
142+13
142+09
142+07
SECTION II
SECTION I
4 PR
5 SE
15 PR
12 SE
5 TE
143+00
142+00
NOTE:
FOR

FIGURE 23

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

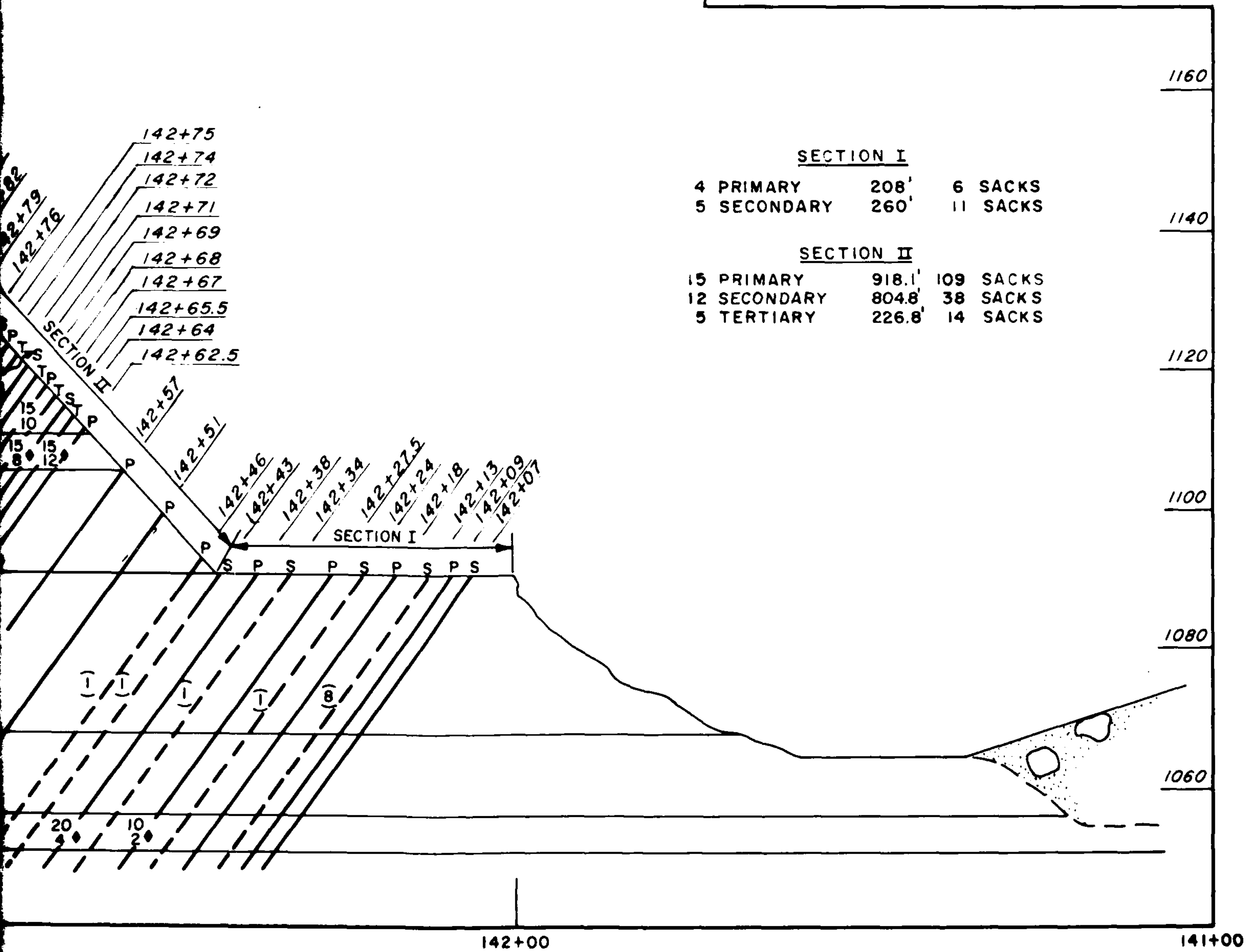
GROUT CURTAIN
LEFT ABUTMENT
(LOOKING DOWNSTREAM)

In 1 sheet Sheet No. 1 Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1938

APRIL 1977



SECTION I

4	PRIMARY	208'	6 SACKS
5	SECONDARY	260'	11 SACKS

SECTION II

15	PRIMARY	918.1'	109 SACKS
12	SECONDARY	804.8'	38 SACKS
5	TERTIARY	226.8'	14 SACKS

NOTE:
FOR LEGEND SEE FIGURE 22.

23

FIGURE 23

2 1 3

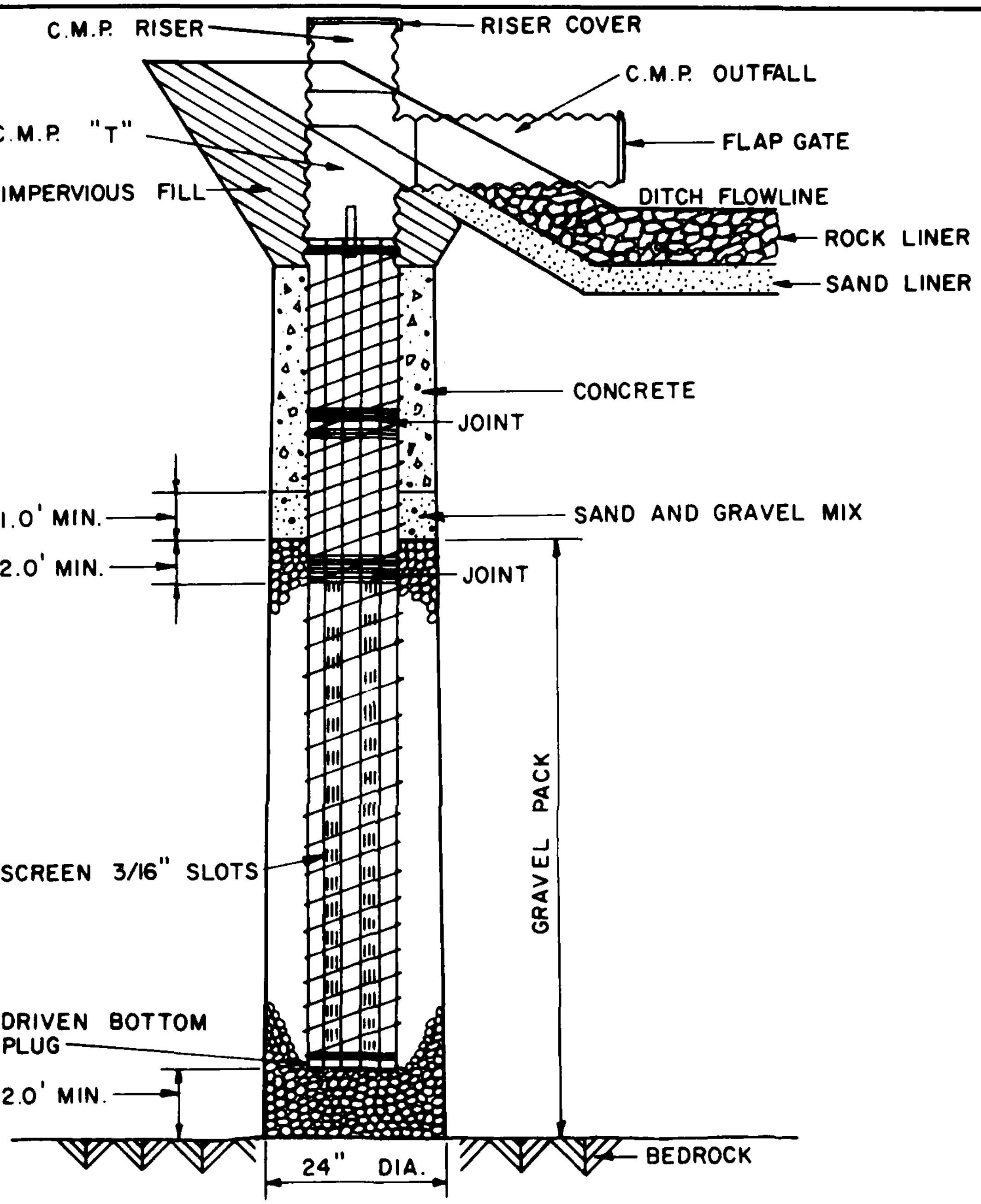


FIGURE 24

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

WELL DETAIL

In 1 sheet Sheet No. 1 Not to scale

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1939

APRIL 1977

FIGURE 24

Hole No. 50

DRILLING LOG	DIVISION Missouri River	INSTALLATION	SHEET OF SHEETS

1. PROJECT: Milford Dam	10. SIZE AND TYPE OF BIT: 24"
2. LOCATION (Coordinates or Station): Sta. 127+50 R. 4+92 ds	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: Construction Dewatering Inc.	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): Well #50	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED Continuous; UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 4-10-65; COMPLETED 4-10-65
7. THICKNESS OF OVERBURDEN: 46.2	17. ELEVATION TOP OF HOLE: 1085.0
8. DEPTH DRILLED INTO ROCK: 0	18. TOTAL CORE RECOVERY FOR BORING: %
9. TOTAL DEPTH OF HOLE: 46.2	19. SIGNATURE OF INSPECTOR: Markwell

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			N. C.	RISER		Drilled with 24" reverse rotary. Change in materials were classified by sampling discharge water with a #30 screen.
1078.8	5		Sand - Fine - Brown			
1077.8			Silt ML			
1077.3			Sand - Fine - Brown			
1075.3	10		SM/ML			Spiders
1073.8			Sand - Very Fine-Brown	1073.9 G.P.		Top of Gravel Pack
1071.8			Sand - Med - Brown SW	1071.9		Top of Screen
1070.3	15		Sand-Fine-Brown/Gray			
1067.8						

Depth	Elevation	Classification	Screen	Remarks
		Sand - Fine - Brown		
	1075.3	SM/ML		Spiders
	1073.8	Sand - Very Fine-Brown	1073.9 G.P.	Top of Gravel Pack
	1071.8	Sand - Med - Brown SW	1071.9	Top of Screen
15	1070.3	Sand-Fine-Brown/Gray		
	1067.8	Sand-Med-Fine-Brown/Gray		Bottom Temp Casing
	1066.3	Hit rock & pushed aside		
	1065.8	Sand-Med-Coarse W/ Gray/Green Gravel		
20	1064.8	Sand-Med. W/Gravel Gray/Green		
25	1058.8	Sand-Fine-Gray/Green	Joint	
30	1054.8	Sand-Med-Gray/Green		
	1052.8	Sand-Med/Coarse-Gray/Green		
35	1049.8	Sand-Coarse-Gray/Green		
	1046.8	Sand-Med Gray/Green		Spiders
40	1045.8	Sand-Coarse-Gray/Green		
	1040.8	Sand-Med-Gray/Green	1040.4 G.P.	Bottom of Screen
45	1038.8	(Water, Green)		
	1038.0	Shale cuttings	1038.2	Taped Depth
		WYMORE SHALE		

Depth scale: 10, 15, 20, 25, 30, 35, 40, 45

SCREEN

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT MILFORD DAM

HOLE NO.

1

2

Depth	Elevation	Classification of materials	Legend	Elevation	Remarks
		Sand-Med-Gray/Green	R		
	1052.8	Sand-Med/Coarse-Gray/Green			
35	1049.8	Sand-Coarse-Gray/Green	C		
	1046.8	Sand-Med Gray/Green			Spiders
40	1045.8	Sand-Coarse-Gray/Green	S		
	1040.8	Sand-Med-Gray/Green		1040.4	Bottom of Screen
45	1038.8	(Water, Green)		G.P.	
	1038.0	Shale cuttings		1038.2	Taped Depth
		WYMORE SHALE			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT MILFORD DAM

HOLE NO.

FIGURE 25

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT

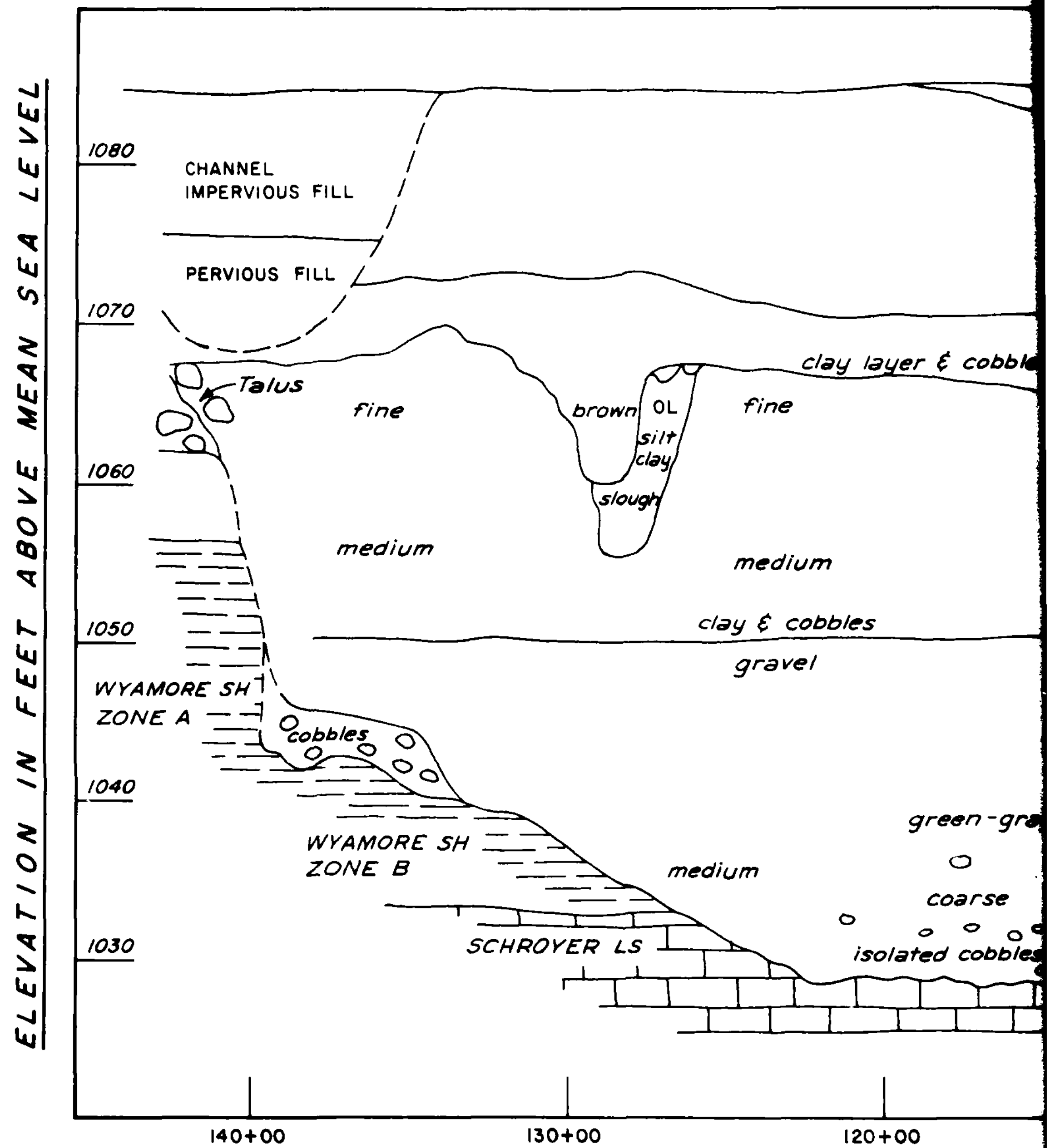
DRILLING LOG
WELL NO. 50

In 1 sheet Sheet No. 1 Scale as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

• FILE NO. B-1-1940

APRIL 1977


ELEVATION IN FEET ABOVE MEAN SEA LEVEL
1080
1070
1060
1050
1040
1030
CHANNEL
IMPERVIOUS FILL
PERVIOUS FILL
clay layer & cobble
Talus
fine
brown
OL
silt
clay
slough
fine
medium
medium
clay & cobbles
gravel
WYAMORE SH
ZONE A
cobbles
WYAMORE SH
ZONE B
medium
green-gra
coarse
SCHROYER LS
isolated cobbles
140+00
130+00
120+00
FI

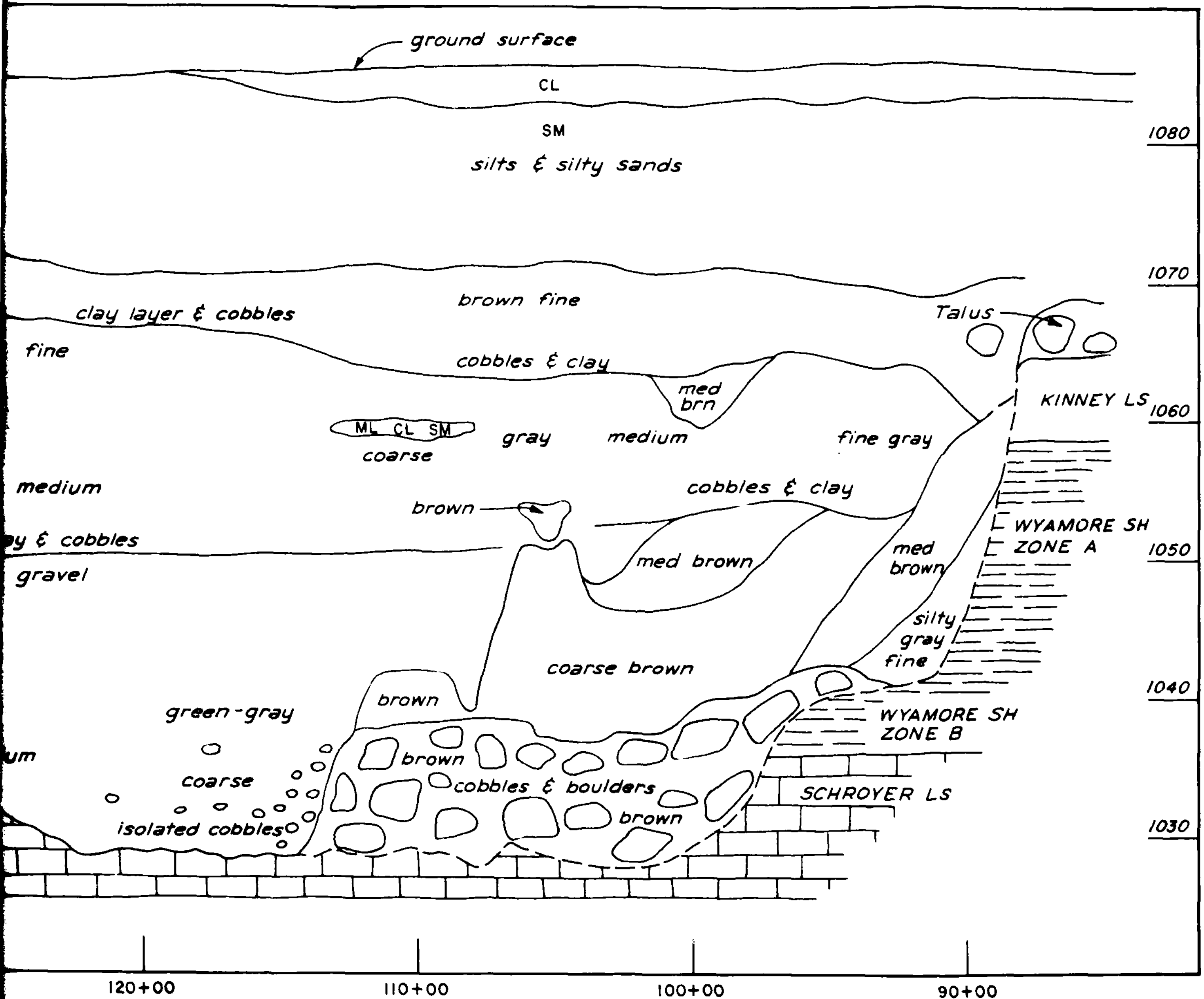


FIGURE 26

NOTE:
FOR LOCATION OF RELIEF WELLS
SEE PLATES NOS. 23 & 24

REPUBLICAN RIVER, KAN

MILFORD LA

FOUNDATION REPOR

PROFILE ALONG RELIEF

(RANGE 4+12 DOWNS

In 1 sheet Sheet No. 1

CORPS OF ENGINEERS U.

KANSAS CITY DISTRI

FILE NO. B-1-1

APRIL 1977

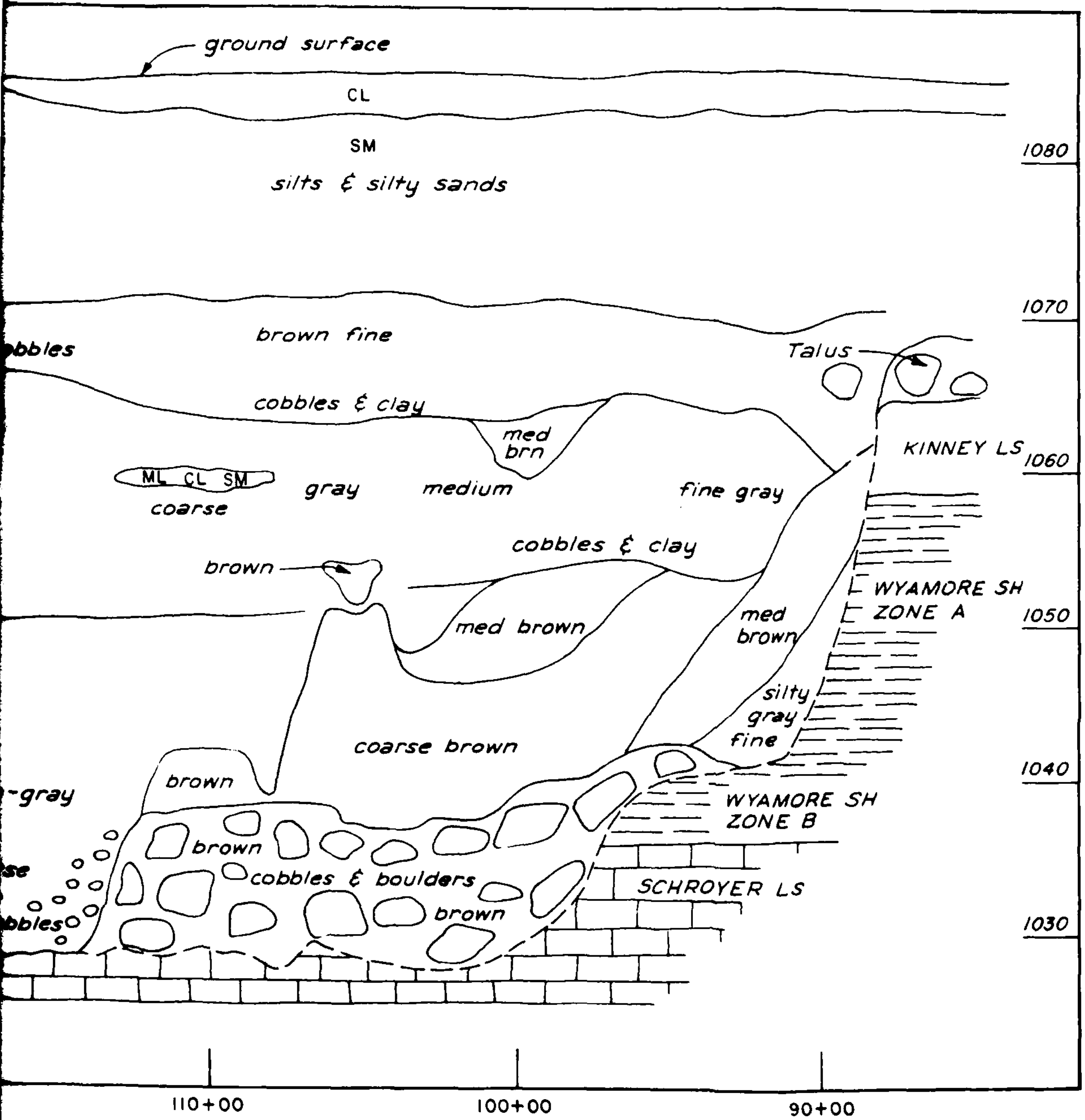


FIGURE 26

NOTE:
FOR LOCATION OF RELIEF WELLS SEE PLATES NOS. 23 & 24

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

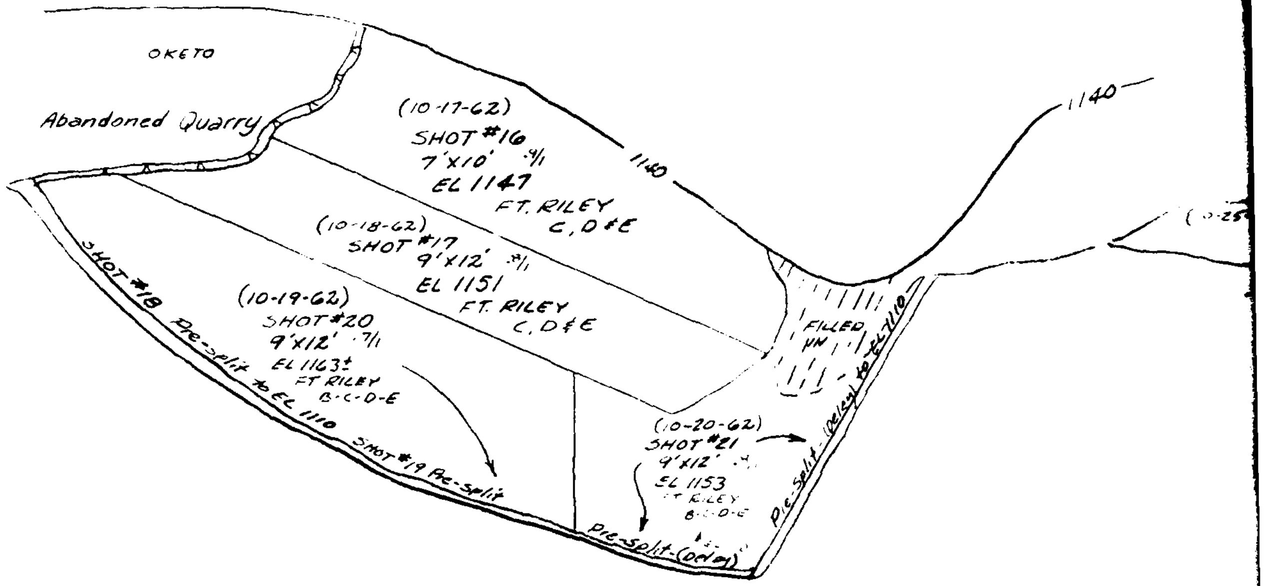
PROFILE ALONG RELIEF WELL LINE (RANGE 4+12 DOWNSTREAM)

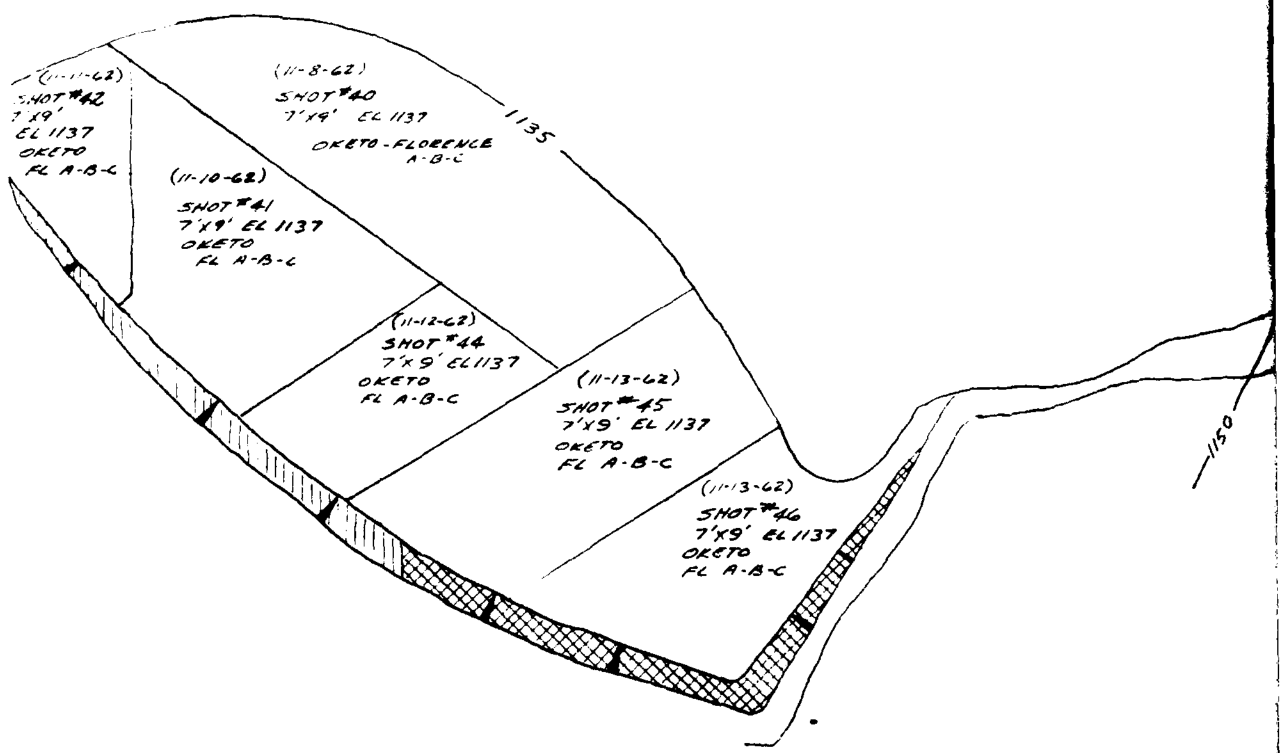
In 1 sheet | Sheet No. 1 | Scale: as shown

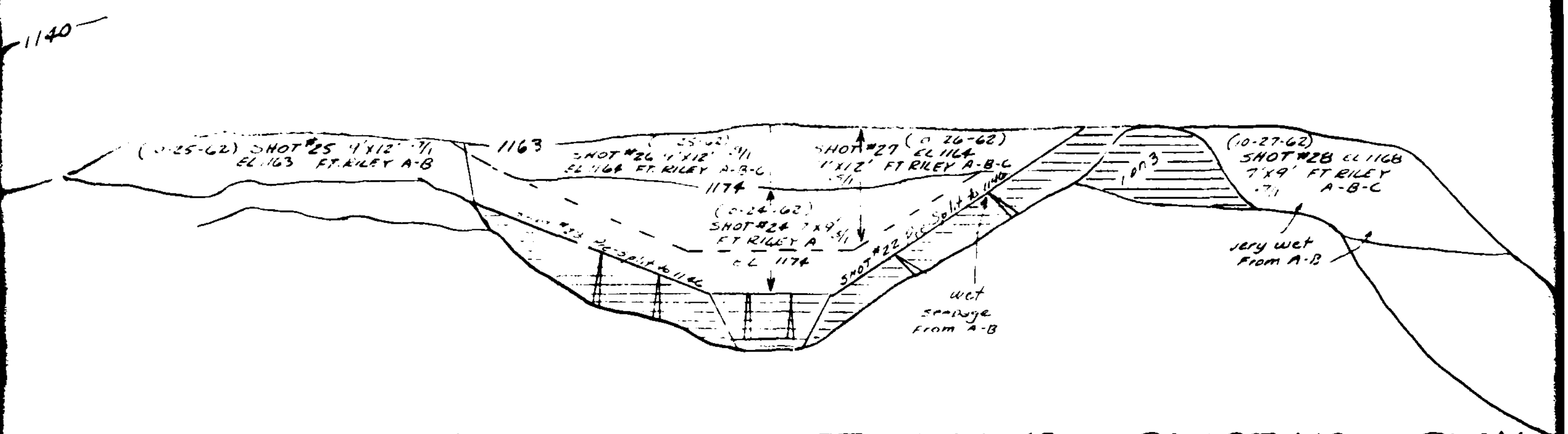
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1941

APRIL 1977


OKETO
Abandoned Quarry
(10-17-62)
SHOT #16
7'x10'
EL 1147
FT. RILEY
C, D & E
(10-18-62)
SHOT #17
9'x12'
EL 1151
FT. RILEY
C, D & E
(10-19-62)
SHOT #20
9'x12'
EL 1163±
FT RILEY
B-C-D-E
(10-20-62)
SHOT #21
9'x12'
EL 1153
FILLED
SHOT #18 Pre-split to EL 1110
SHOT #19 Pre-split
Pre-Split-(delay)
Pre-Split-(delay) to EL 1110
1140
1140


(11-11-62)
SHOT #42
7'x9'
EL 1137
OKETO
FL A-B-C
(11-8-62)
SHOT #40
7'x9' EL 1137
OKETO-FLORENCE
A-B-C
1135
(11-10-62)
SHOT #41
7'x9' EL 1137
OKETO
FL A-B-C
(11-12-62)
SHOT #44
7'x9' EL 1137
OKETO
FL A-B-C
(11-13-62)
SHOT #45
7'x9' EL 1137
OKETO
FL A-B-C
(11-13-62)
SHOT #46
7'x9' EL 1137
OKETO
FL A-B-C
1150



MILFORD DAM OUTLET WORKS BLASTING PLAN
1st LIFT
Scale 40 feet

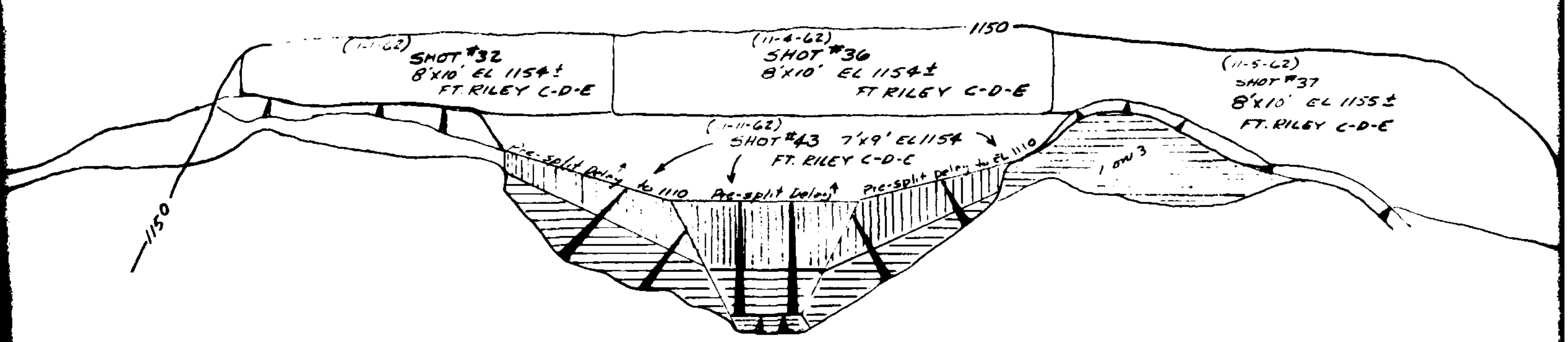
REPUBLICAN RIVER KANSAS
MILFORD LAKE
FOUNDATION REPORT

OUTLET WORKS
BLASTING PLAN
IST AND 2ND LIFTS

In 1 sheet | Sheet No. 1

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1942
APRIL 1977



MILFORD DAM OUTLET WORKS BLASTING PL
2nd LIFT
Scale 40 feet

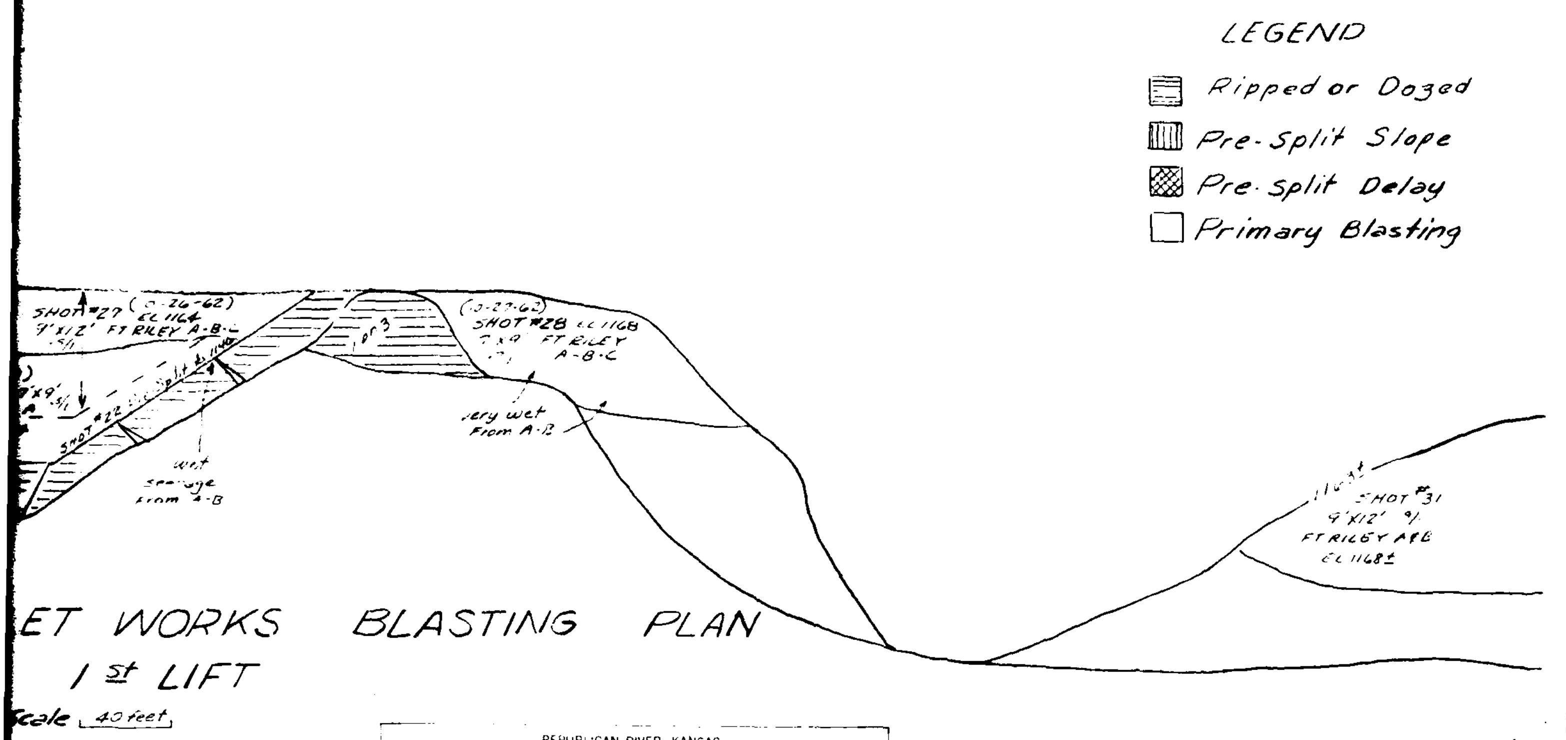


FIGURE 27

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

OUTLET WORKS
BLASTING PLAN
1ST AND 2ND LIFTS

In 1 sheet   Sheet No. 1   Scale: as shown

CORPS OF ENGINEERS   U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1942

APRIL 1977

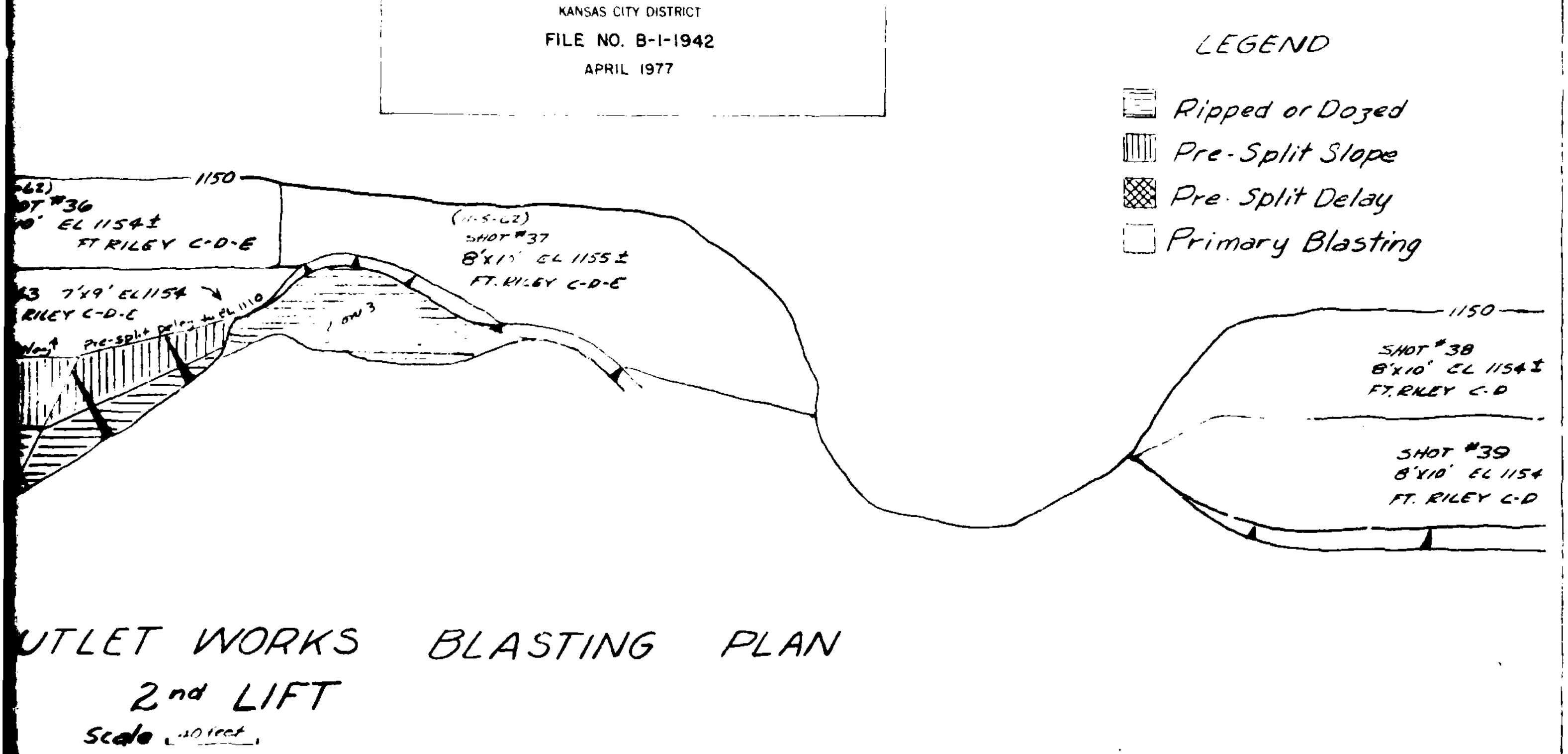
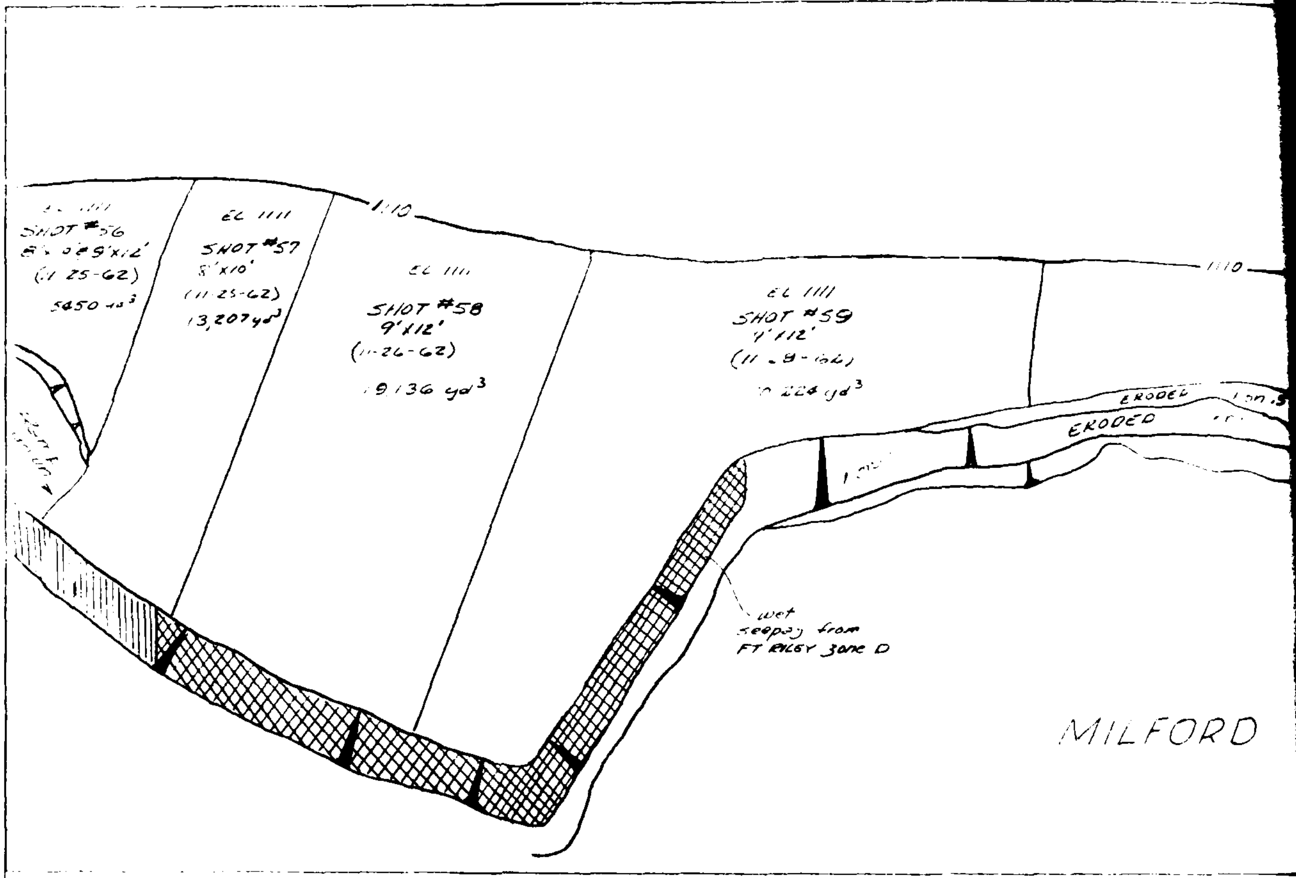
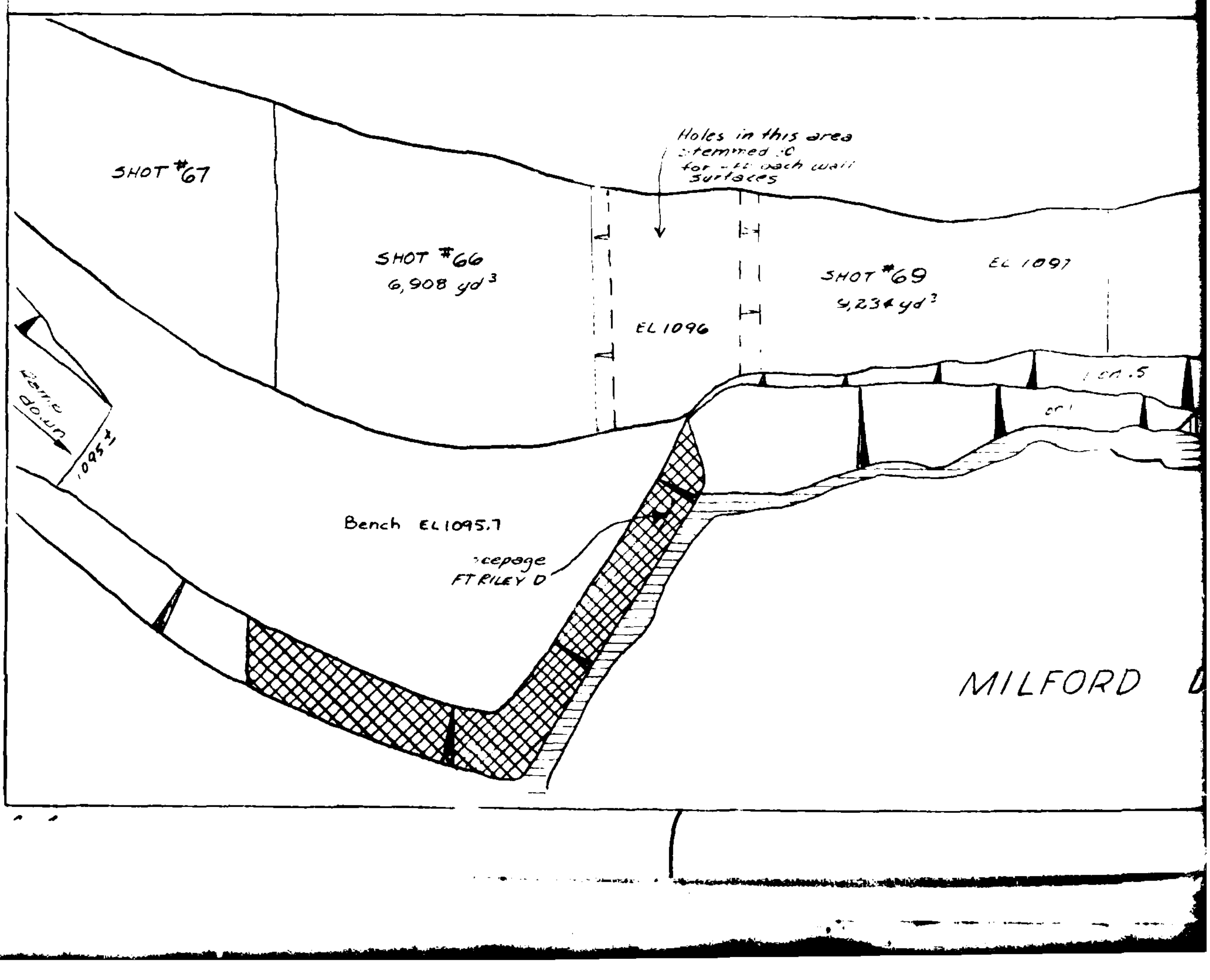


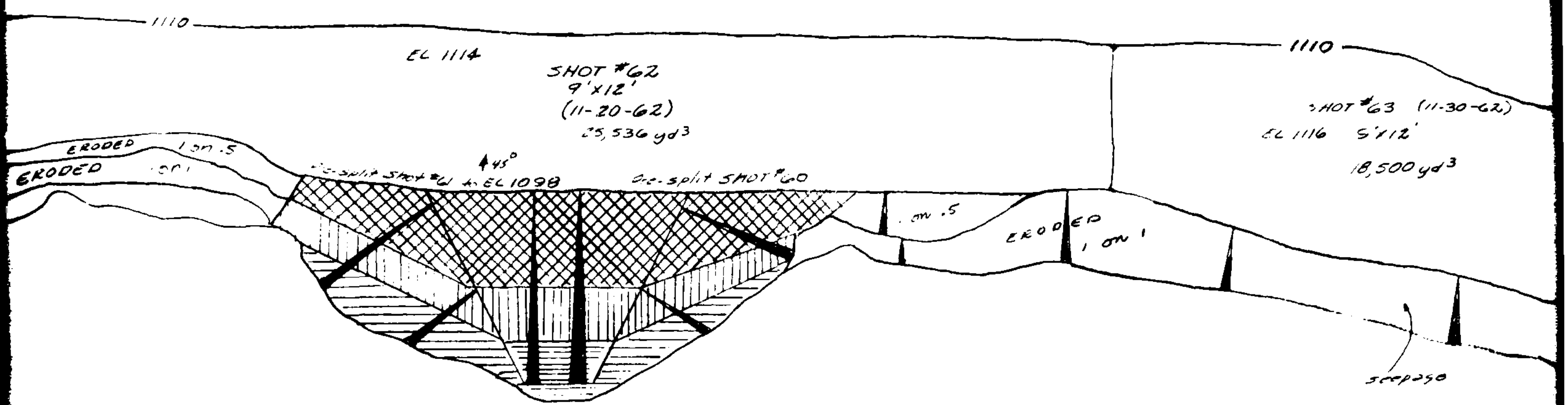
FIGURE 28

FIGURES 27 & 28

3

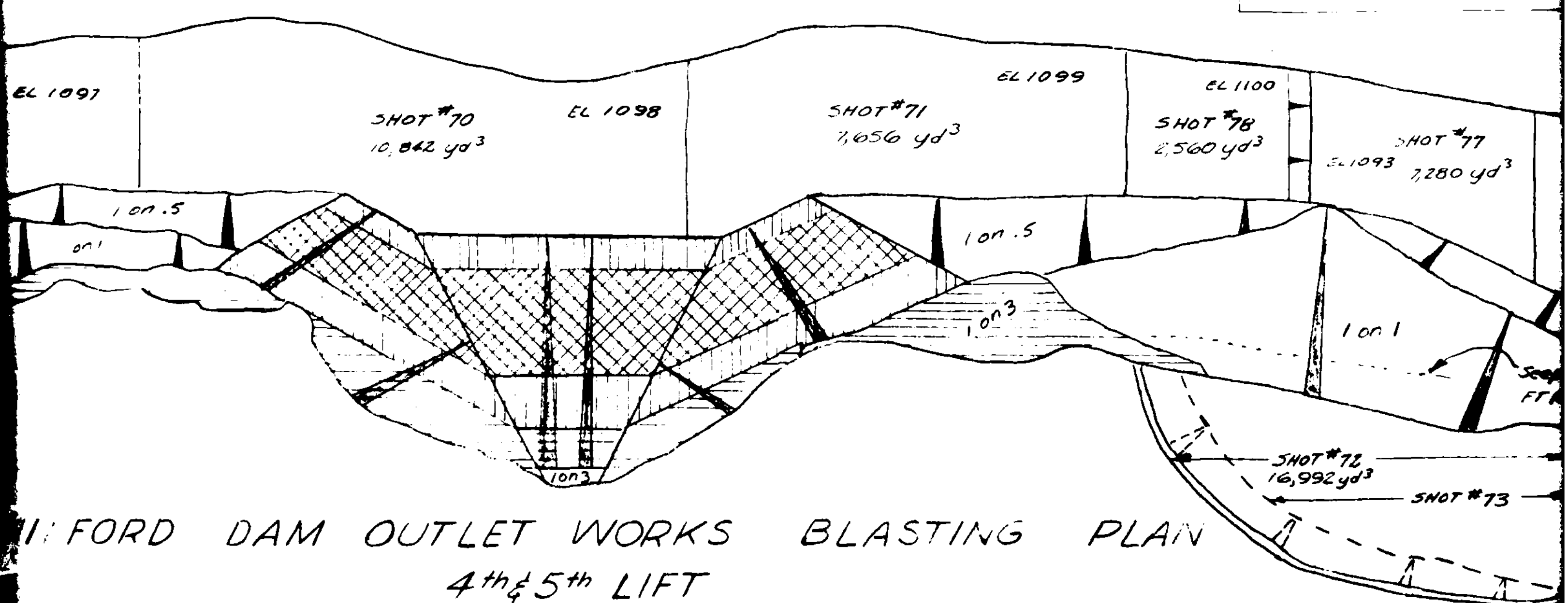

SHOT #56
SHOT #57
8'x10'
(11-25-62)
13,207 yd³
EL 1111
SHOT #58
9'x12'
(11-26-62)
EL 1111
SHOT #59
1110
ERODED
ERODED
wet
seepage from
FT RILEY zone D
MILFORD


Holes in this area
SHOT #67
SHOT #66
6,908 yd³
EL 1096
SHOT #69
EL 1097
Bench EL 1095.7
seepage
FT RILEY D
MILFORD



MILFORD DAM OUTLET WORKS BLASTING PLAN
3rd & 4th LIFT
Scale 10 feet

REPUBLICAN RIVER, KANS
MILFORD LA
FOUNDATION REPORT
OUTLET WORKS
BLASTING PLAN
3RD, 4TH AND 5TH
In 1 sheet
Sheet No. 1
CORPS OF ENGINEERS U.
KANSAS CITY DISTRICT
FILE NO. B-1-194
APRIL 1977



MILFORD DAM OUTLET WORKS BLASTING PLAN
4th & 5th LIFT
Scale 10 feet

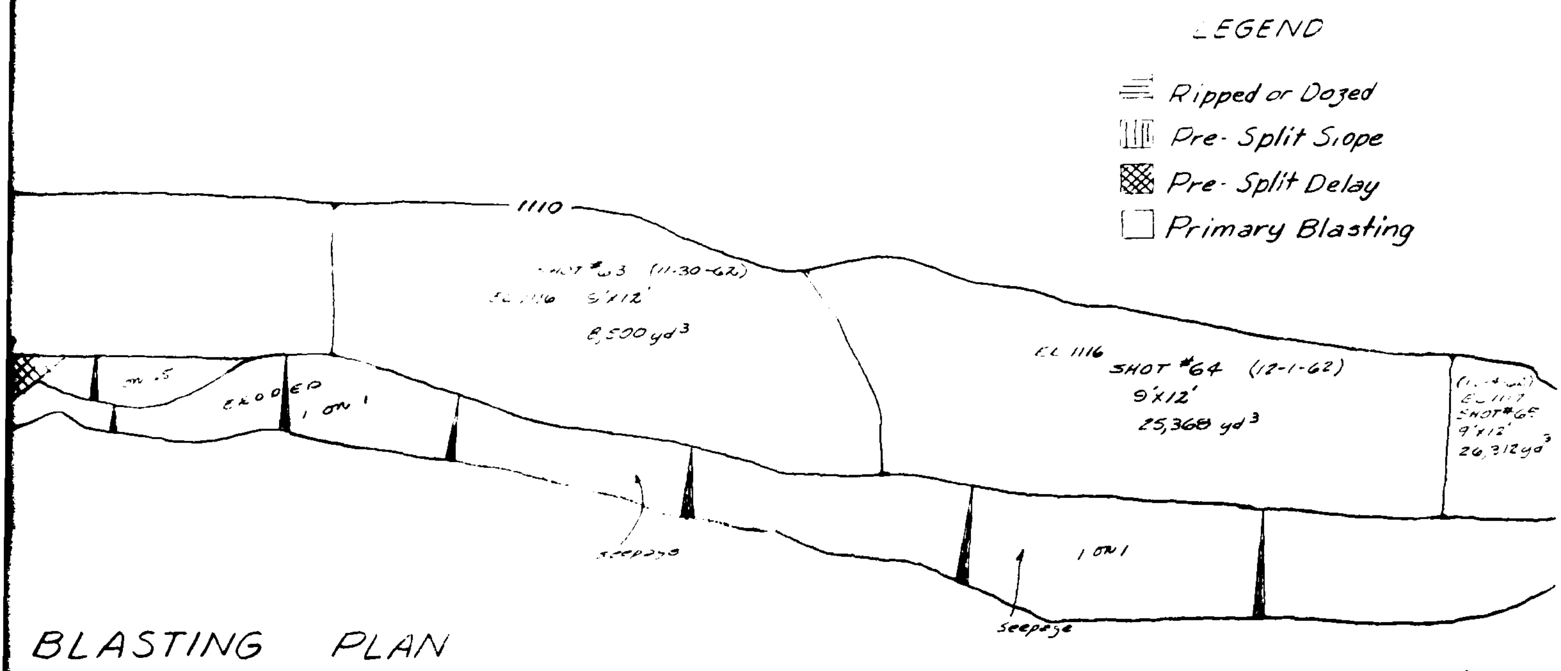


FIGURE 29

REPUBLICAN RIVER KANSAS

MILFORD LAKE

FOUNDATION REPORT

OUTLET WORKS
BLASTING PLAN
3RD, 4TH AND 5TH LIFTS

In sheet | Sheet No | Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1943

APRIL 1977

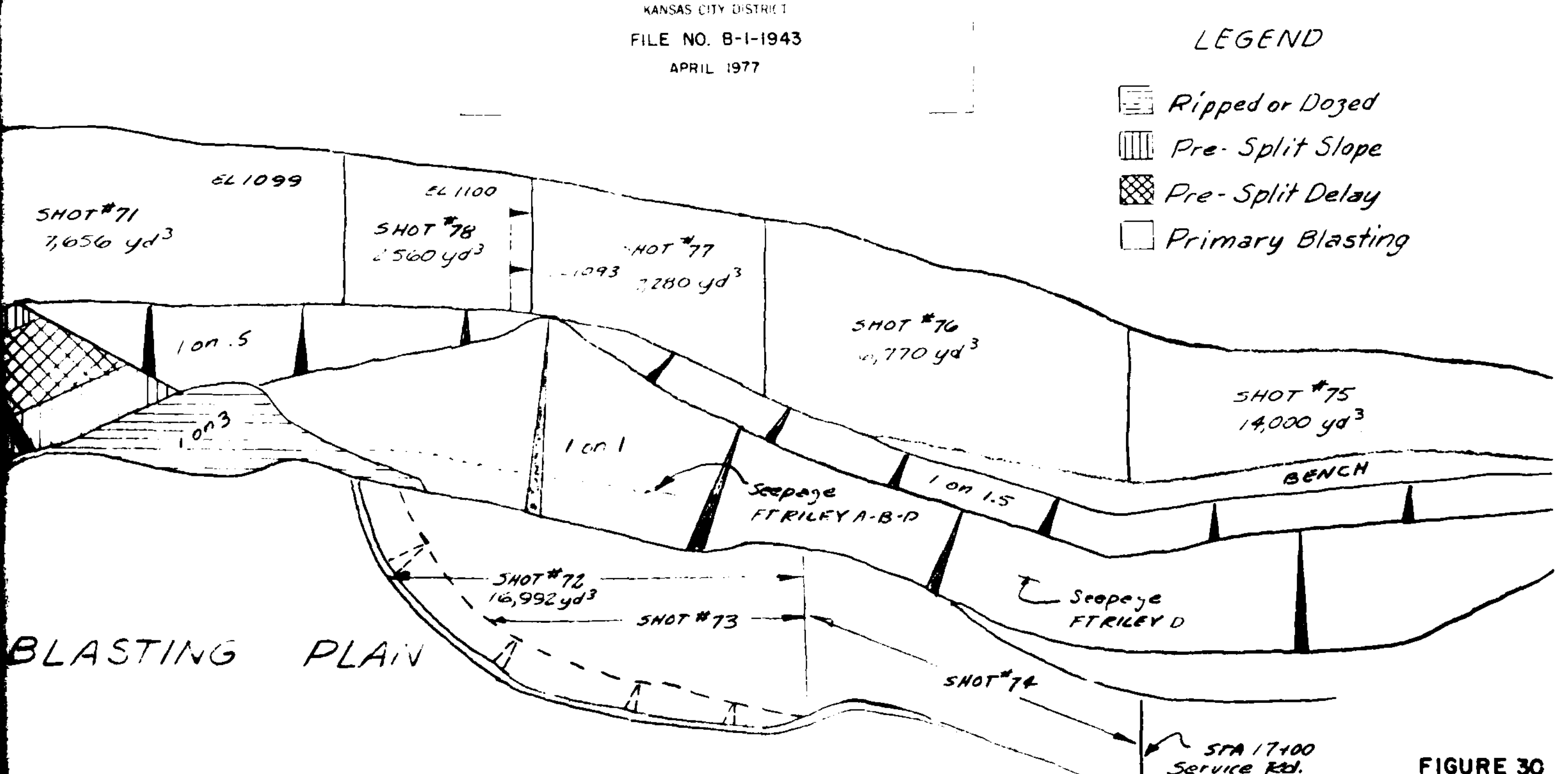
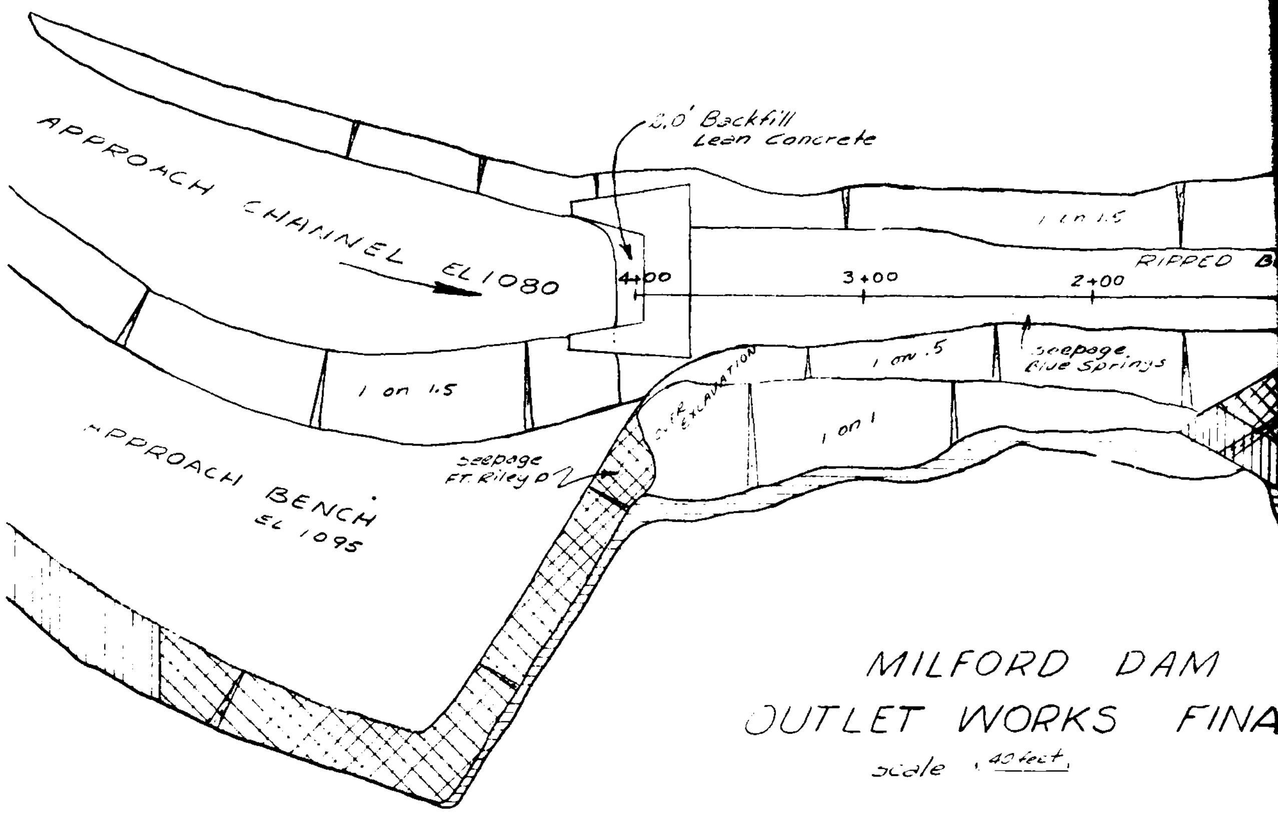


FIGURE 30

FIGURES 29 & 30

2 1 3



MILFORD DAM
OUTLET WORKS FINA

scale 40 feet

FIG 33

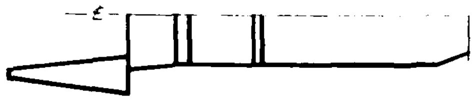


FIG 34

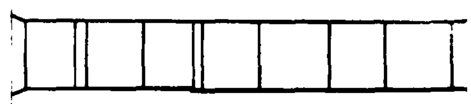
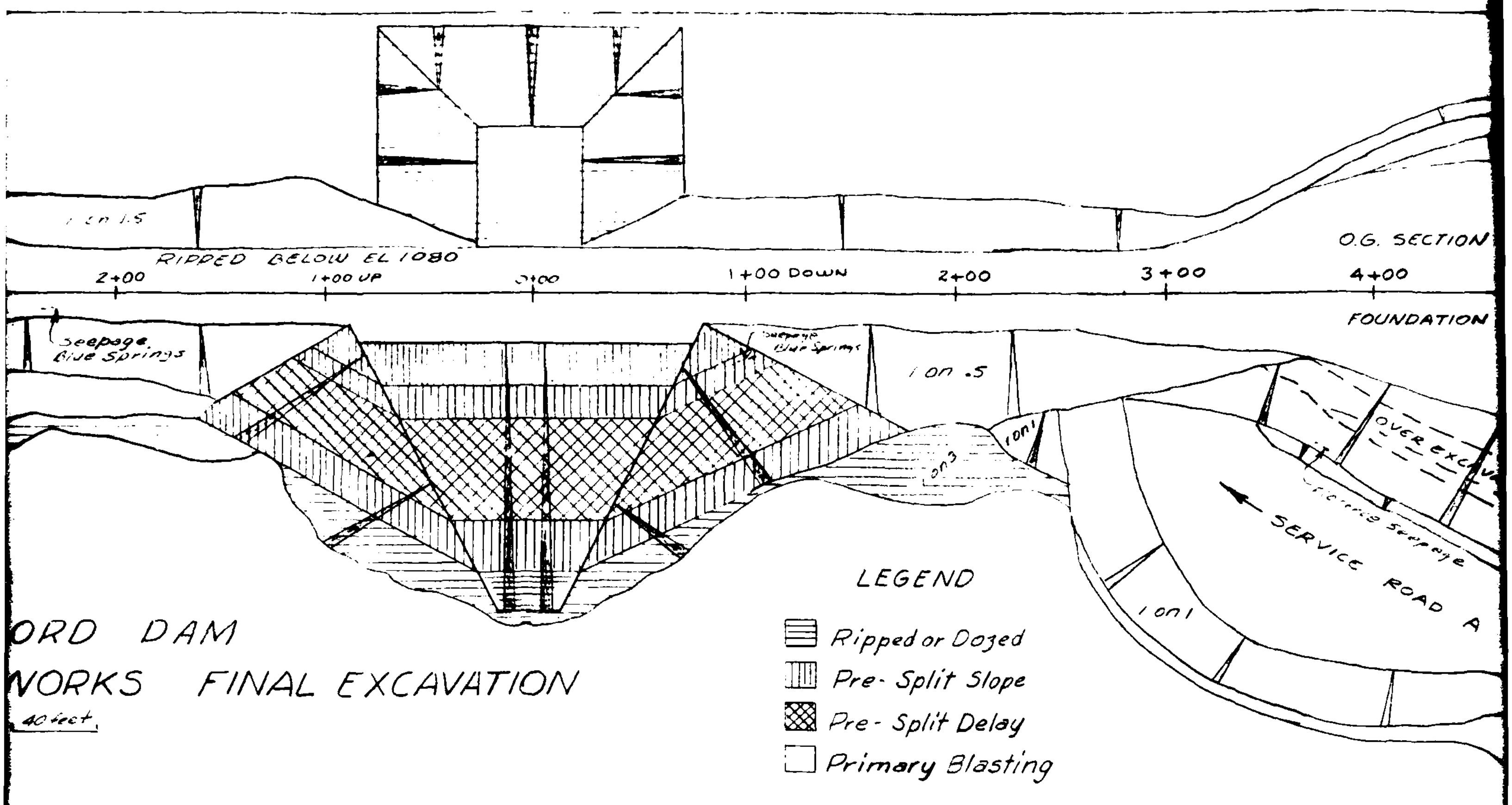


FIG 35

MILFORD DAM FOUNDATION

1



REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

OUTLET WORKS
FINAL EXCAVATION PLAN
INDEX OF FOUNDATION MAPS

In 1 sheet | Sheet No. 1 | Scale as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1944

APRIL 1977

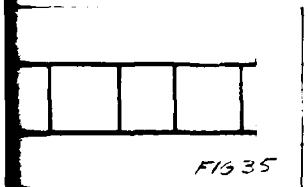


FIG 35

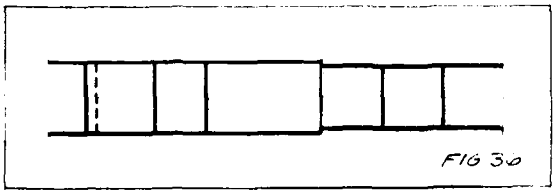


FIG 36

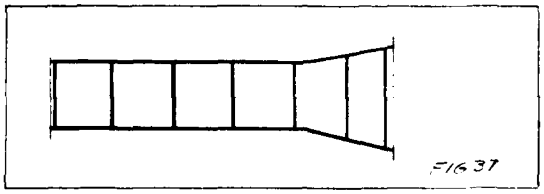


FIG 37

FOUNDATION MAP OUTLET WORKS INDEX SHEET FOR FIGURES 33 TH

no Scale

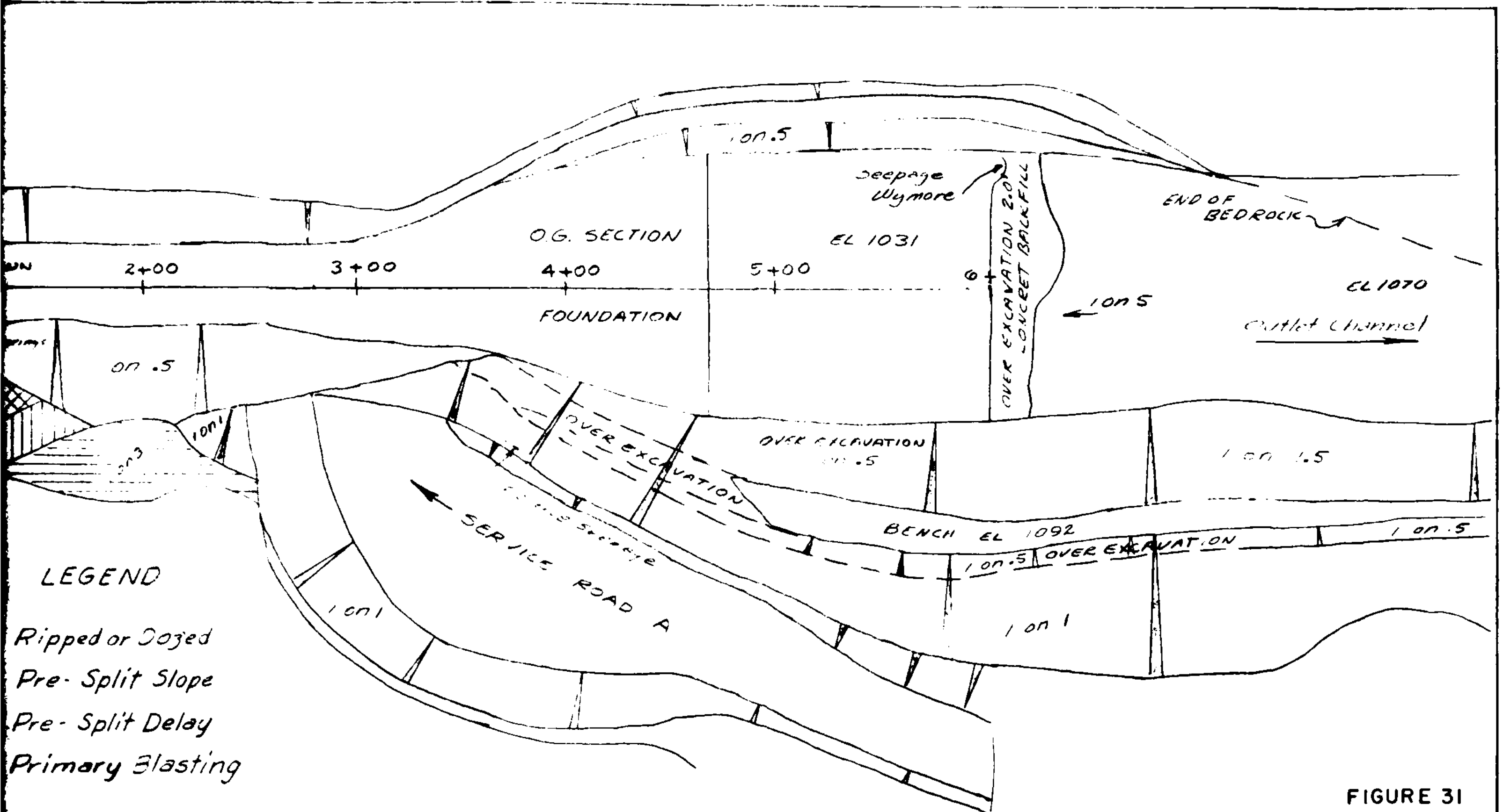


FIGURE 31

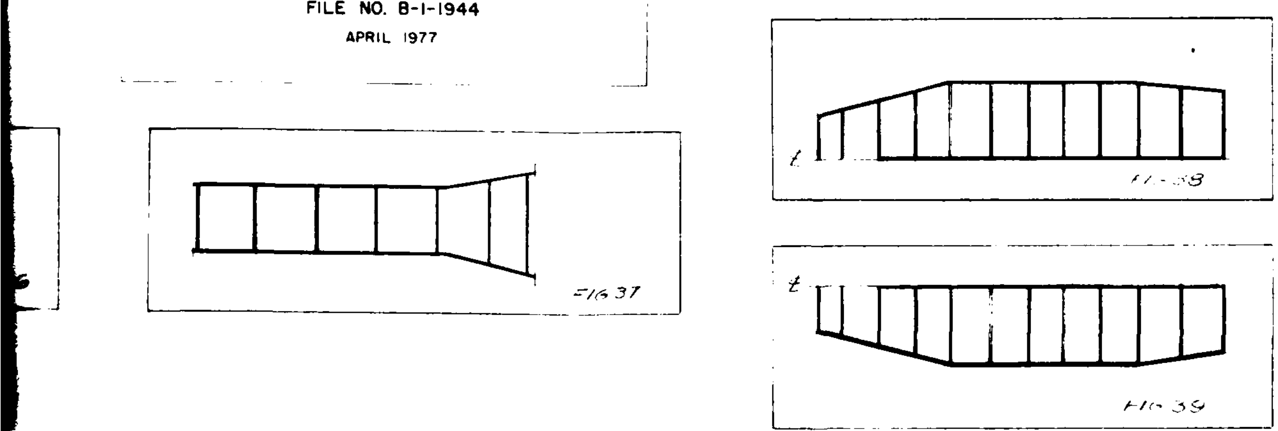
REPUBLICAN RIVER KANSAS
MILFORD LAKE
FOUNDATION REPORT

OUTLET WORKS
FINAL EXCAVATION PLAN
INDEX OF FOUNDATION MAPS

In 1 sheet | Sheet No | Scale as shown

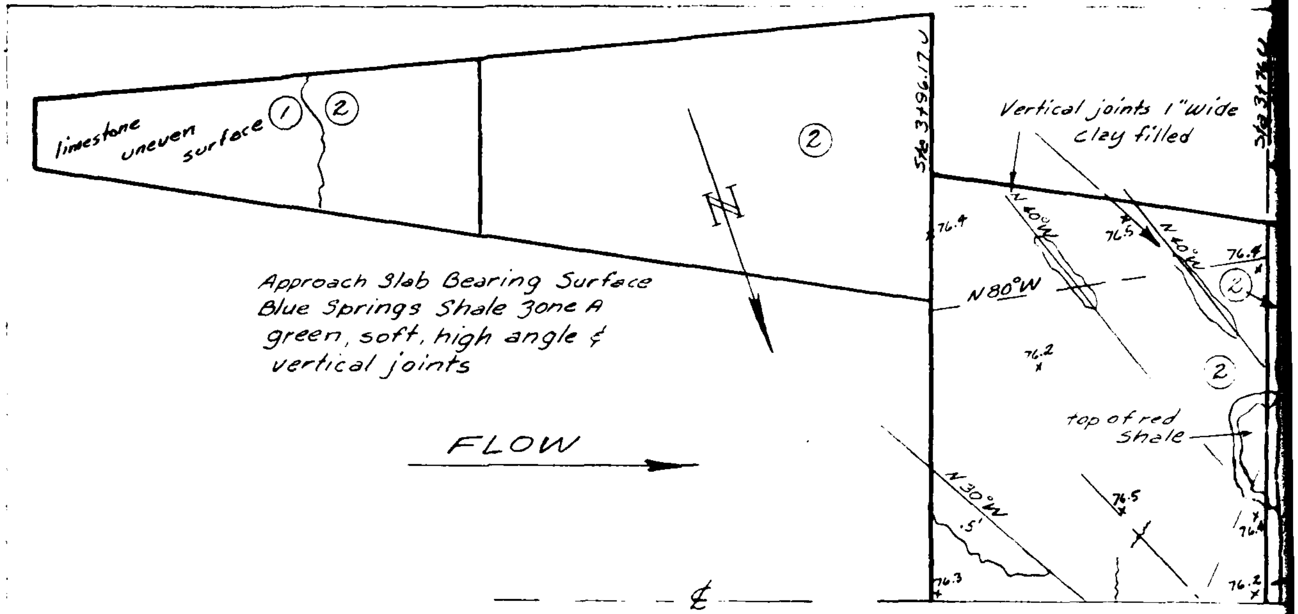
CORPS OF ENGINEERS U S ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1944
APRIL 1977



INDEX SHEET FOR FIGURES 33 THRU 39

FIGURE 32



LEGEND

(1) Limestone Blue Springs zone A

(2) Green clay shale Blue Springs zone A

(3) Red clay shale Blue Springs zone A

(4) Dark gray calcareous Shale Blue Springs zone B

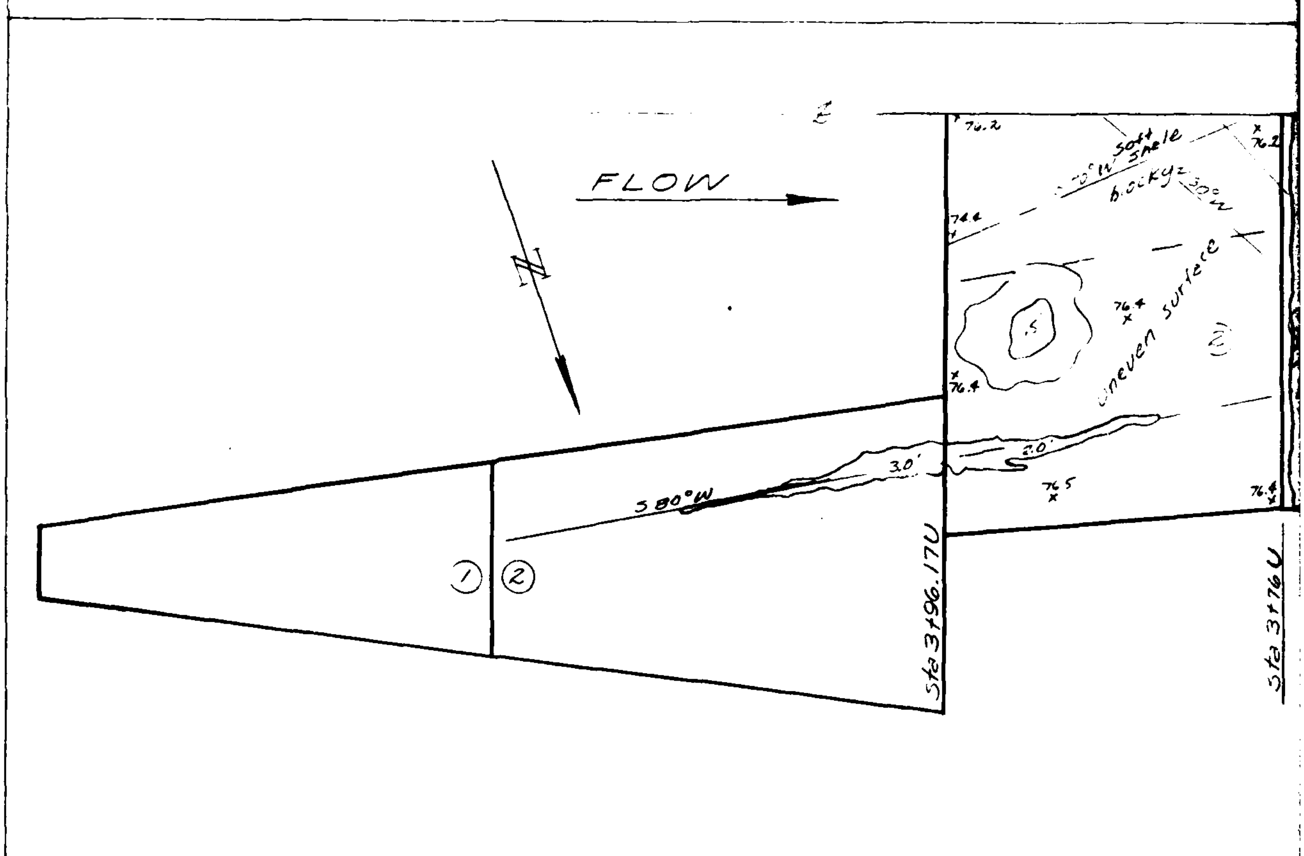
(5) Soft Shale Blue Springs zone B

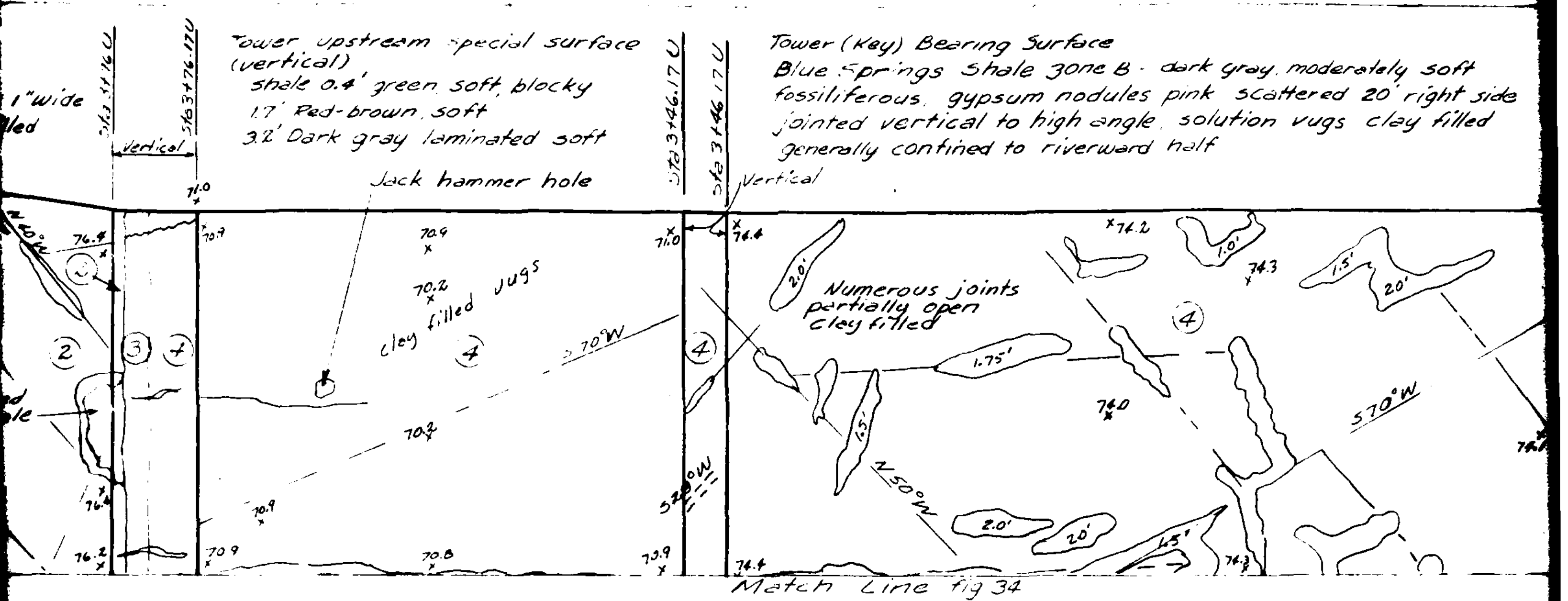
(6) Hard gray limestone Kinney

(7) H... W...

(8) S... V...

(9) H... Sc...





(7) Hard calcareous shale Wymore zone A

(8) Soft dark shale Wymore zone B

(9) Hard white upper Schroyer limestone

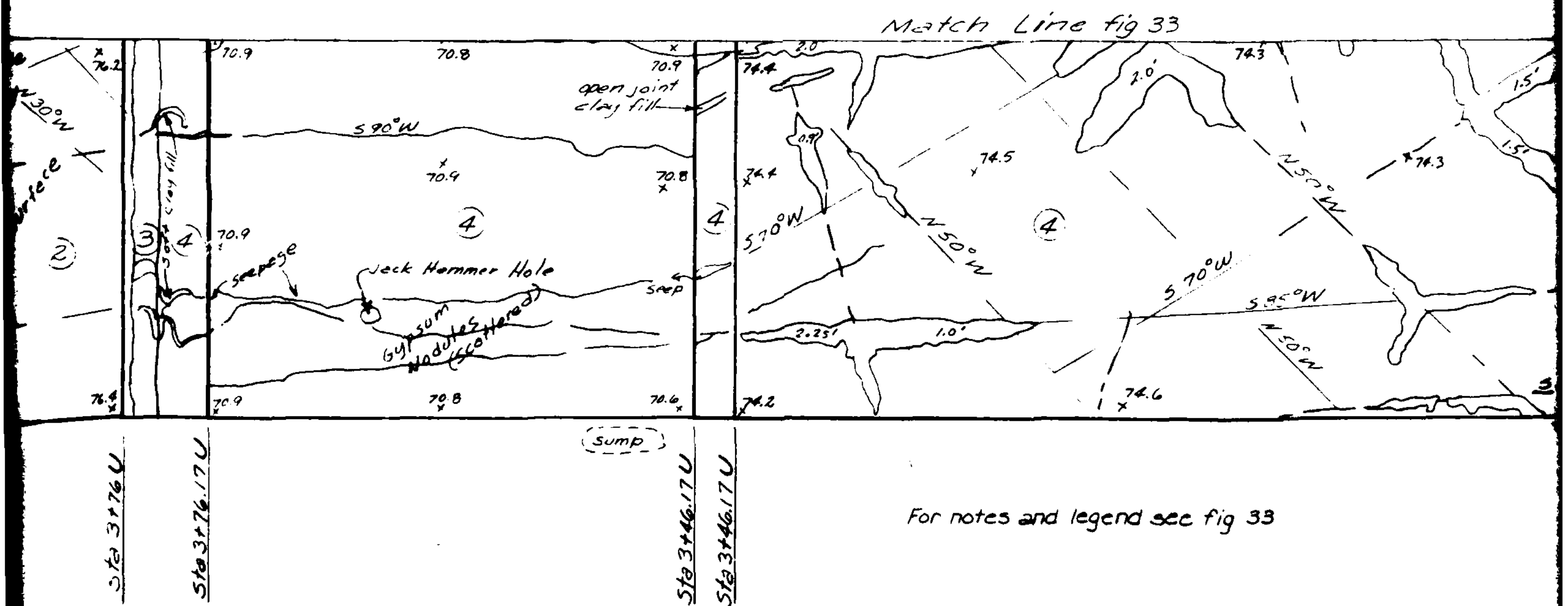
(10) Dark argillaceous limestone upper Schroyer

(11) Dark very argillaceous limestone lower Schroyer

(12) Hard thin cherty limestone lower Schroyer

MILFORD DAM FOUNDATIO

scale 6



For notes and legend see fig 33

MILFORD DAM FOUNDATION MAP OUTLET WORKS

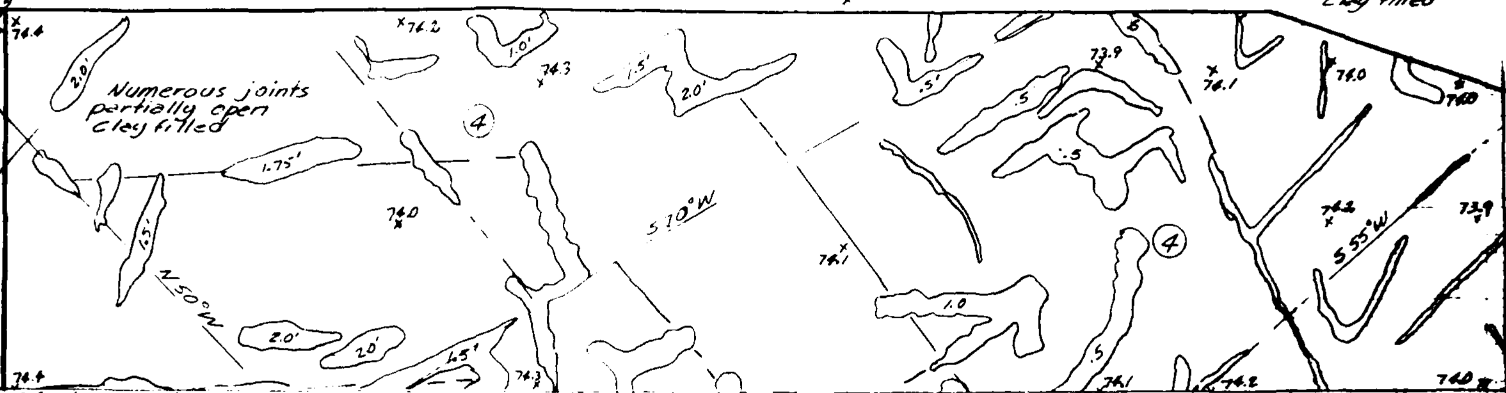
2 scale 6 feet

1

Tower (Key) Bearing Surface
Blue Springs Shale zone B - dark gray moderately soft fossiliferous gypsum nodules pink scattered 20 right side jointed vertical to high angle solution vugs clay filled generally confined to riverward half

Tower downstream special surface (vertical)
2.3' shale, dark grey, laminated, soft
0.7' shale, calcareous, laminae
excavated, cleaned and gunited

Tower Bearing Surface - Blue Springs shale zone B dark grey, numerous joints open or clay filled



Match Line fig 34

stone

MILFORD DAM FOUNDATION MAP OUTLET WORKS
Scale 6 feet

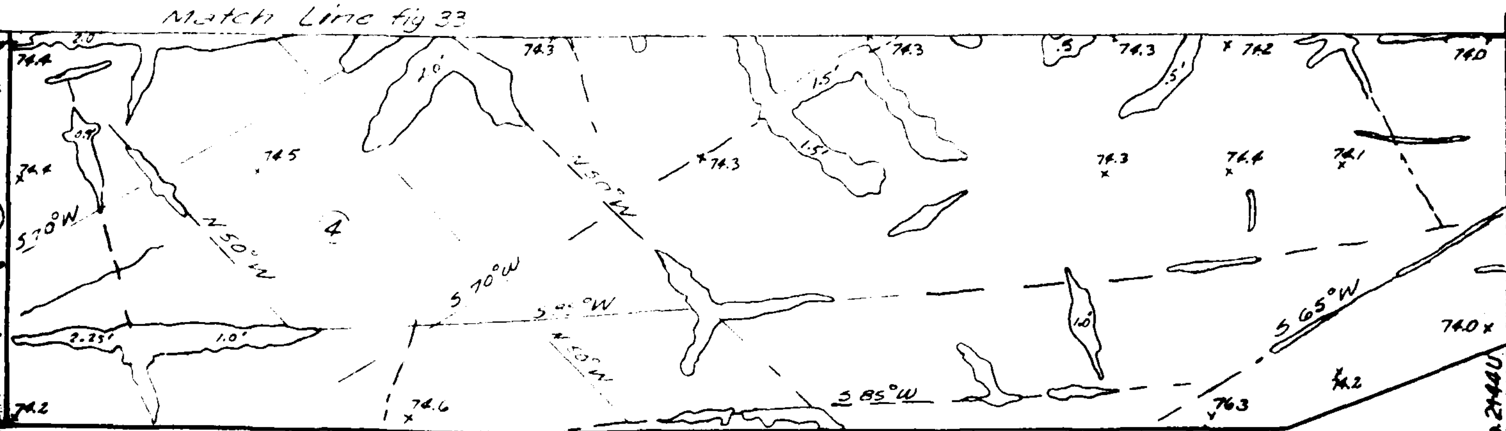
us limestone

limestone

Sta. 2+44 U

FIGURE 33

Match Line fig 33



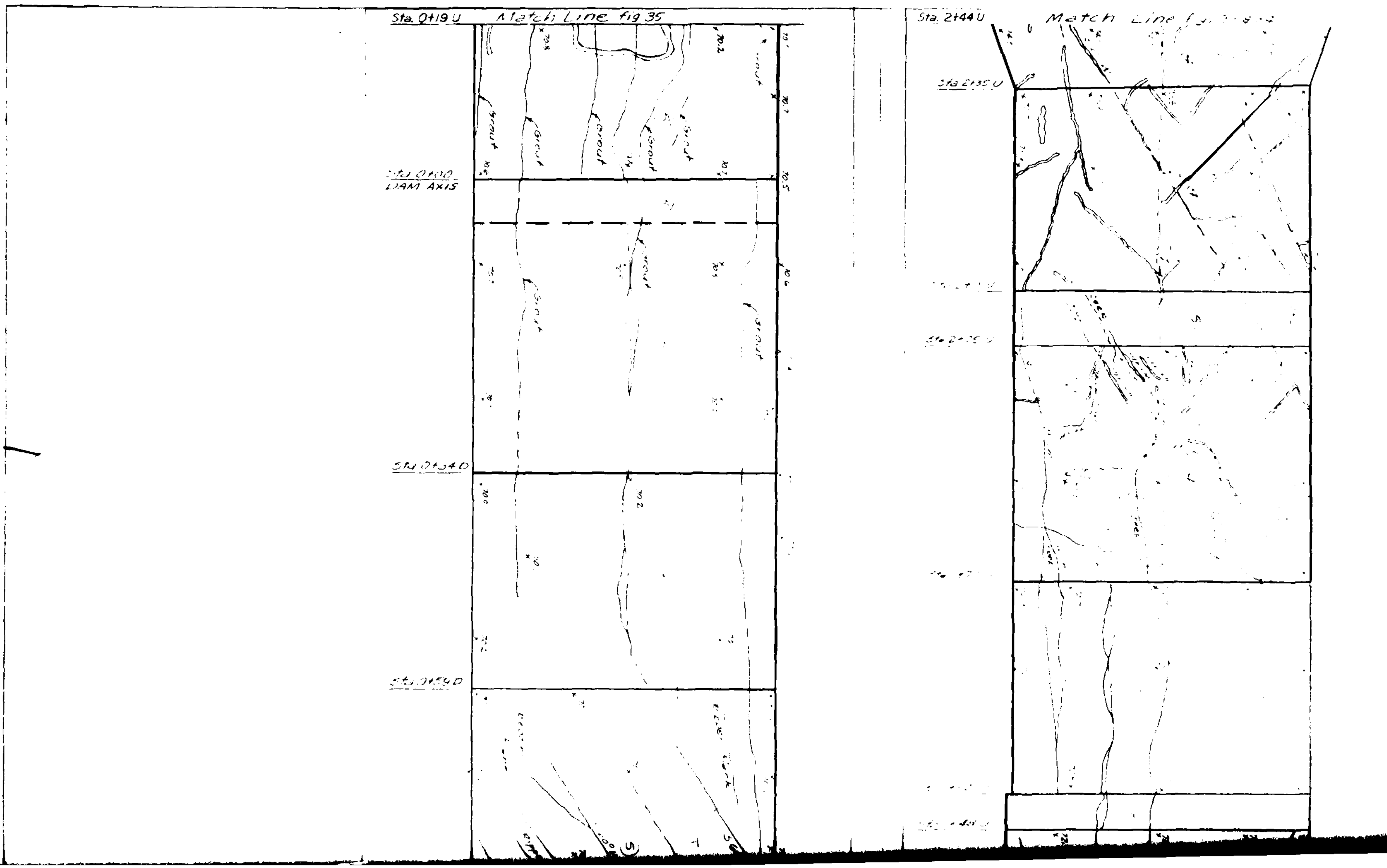
For notes and legend see fig 33

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
FOUNDATION REPORT
OUTLET WORKS
FOUNDATION MAP OF
LEFT AND RIGHT HALVES
STA. 4+55 UPSTREAM
TO STA. 2+44 UPSTREAM
In 1 sheet Sheet No. 1 Scale: as shown
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT
FILE NO. B-1-1946
APRIL 1977

ATION MAP OUTLET WORKS
le 6 feet

FIGURE 34

FIGURES 33 & 34



Sta. 0+19 U
Match Line fig 35
Sta. 0+00
DAM AXIS
Sta. 0+34 D
Sta. 0+49 D
Grout
Sta. 2+44 U
Match Line
Sta. 2+35 U

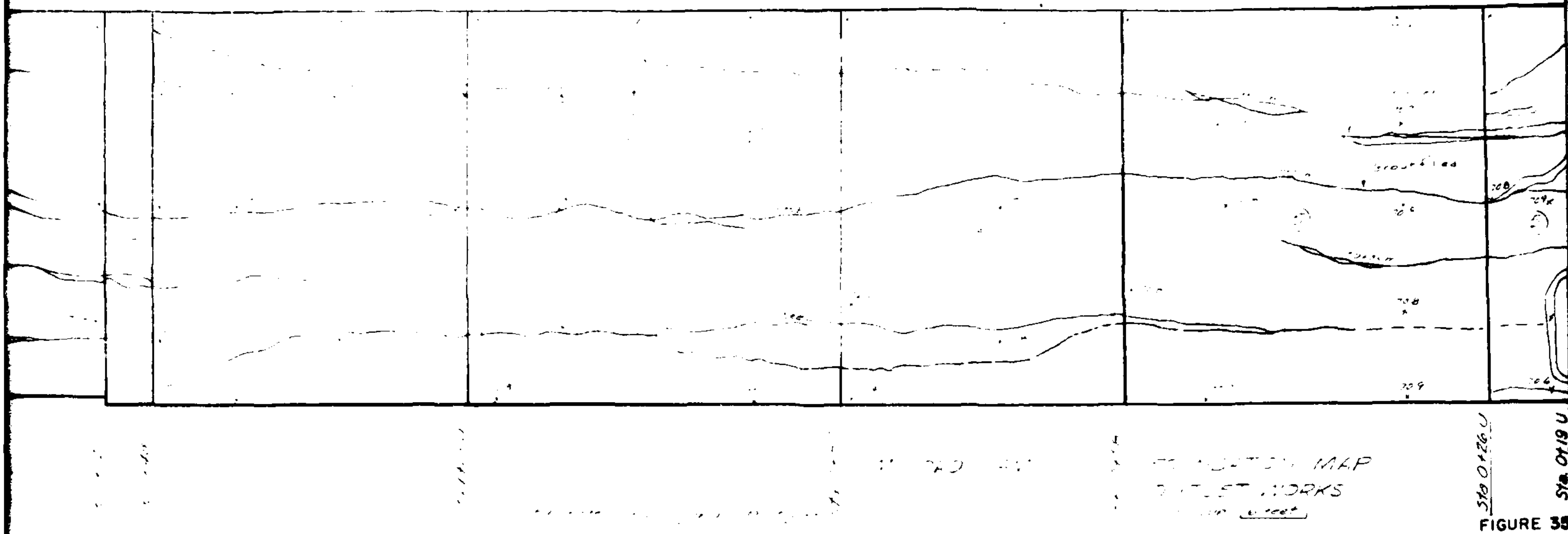


FIGURE 35

FIGURE 36

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

OUTLET WORKS
FOUNDATION MAP
STA. 2+44 UPSTREAM
TO STA. 2+08 DOWNSTREAM

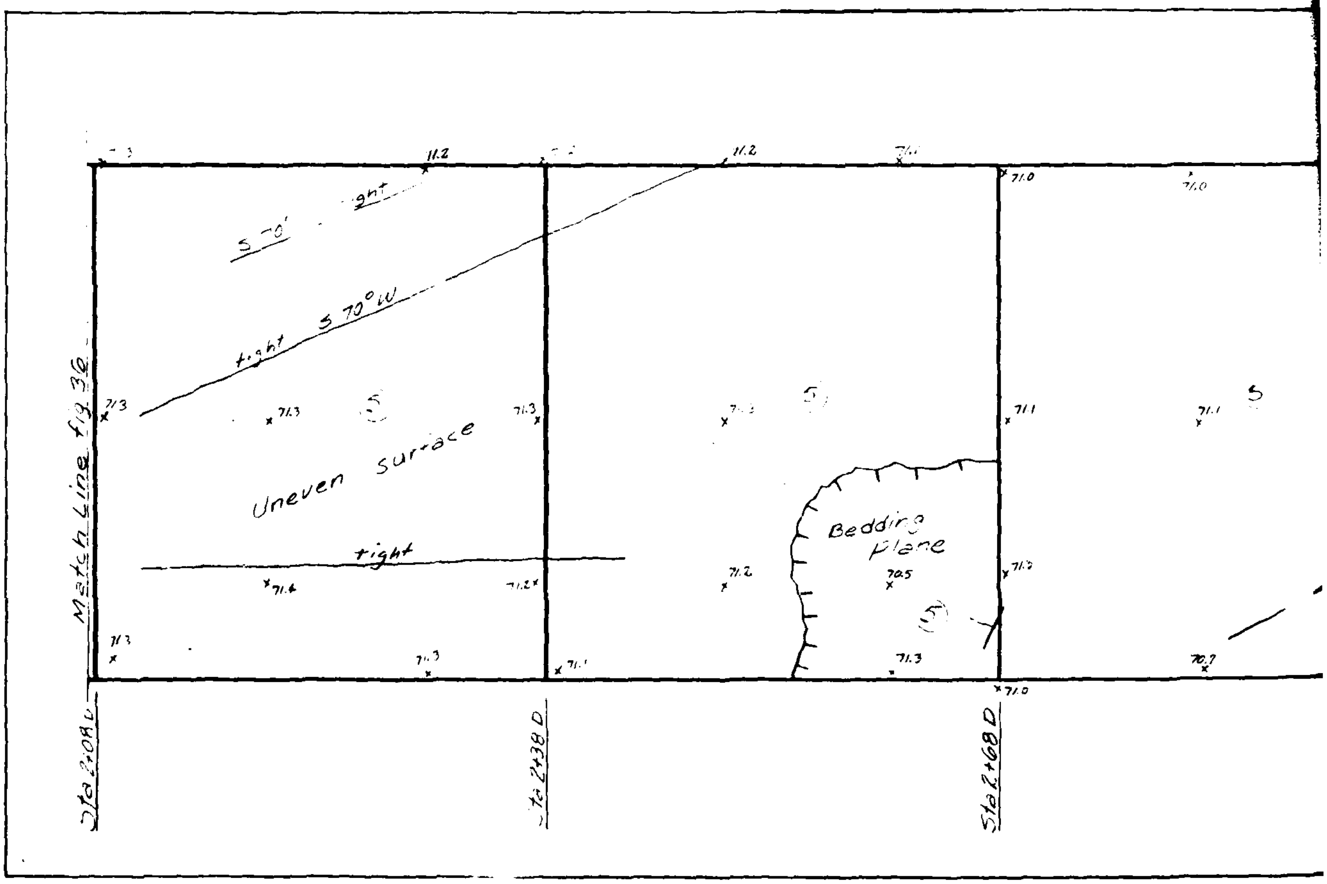
In 1 sheet | Sheet No. 1 | Scale: as shown

CORPS OF ENGINEERS U S ARMY
KANSAS CITY DISTRICT

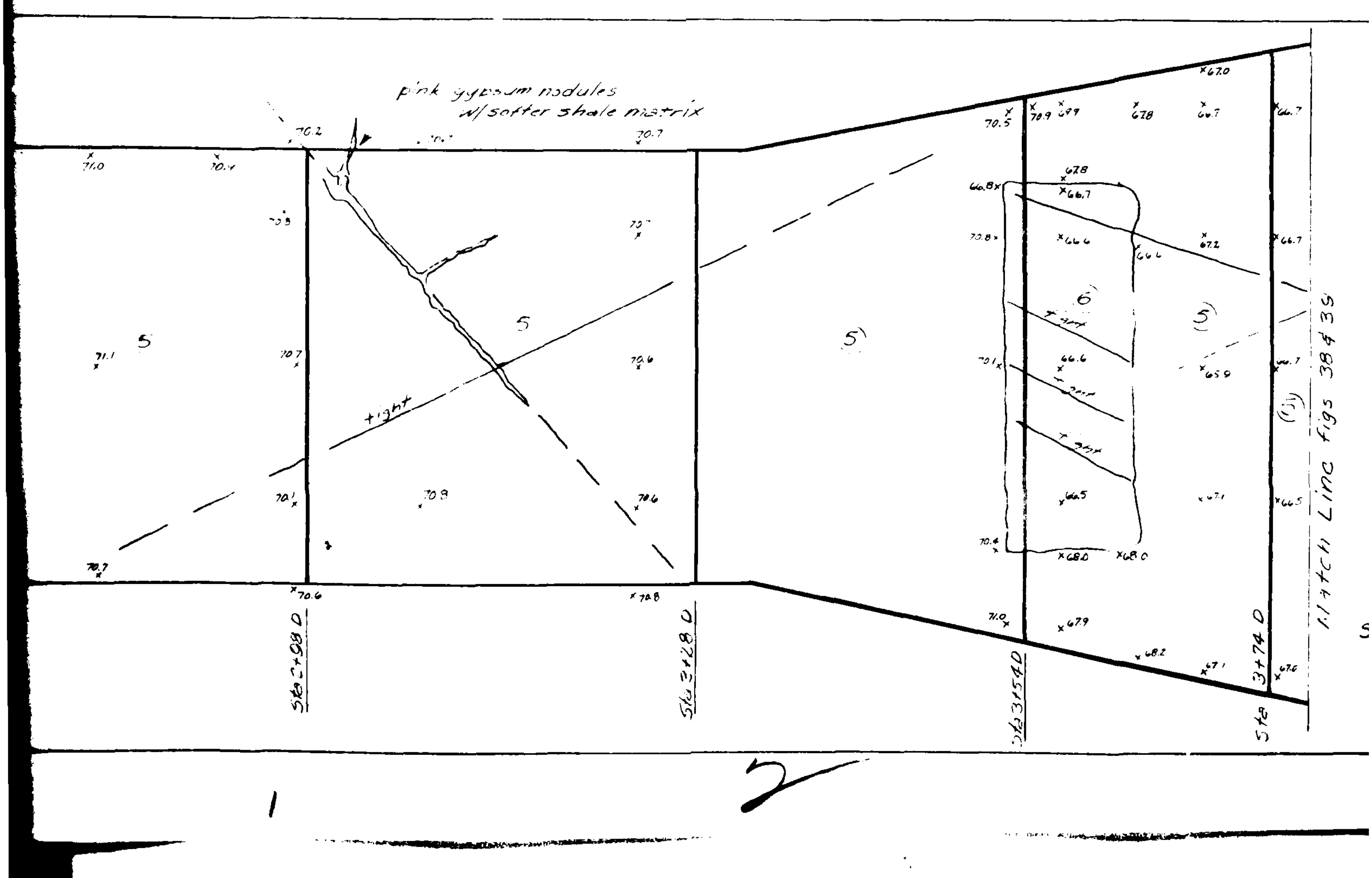
FILE NO. B-1-1946

APRIL 1977

FIGURES 35 &

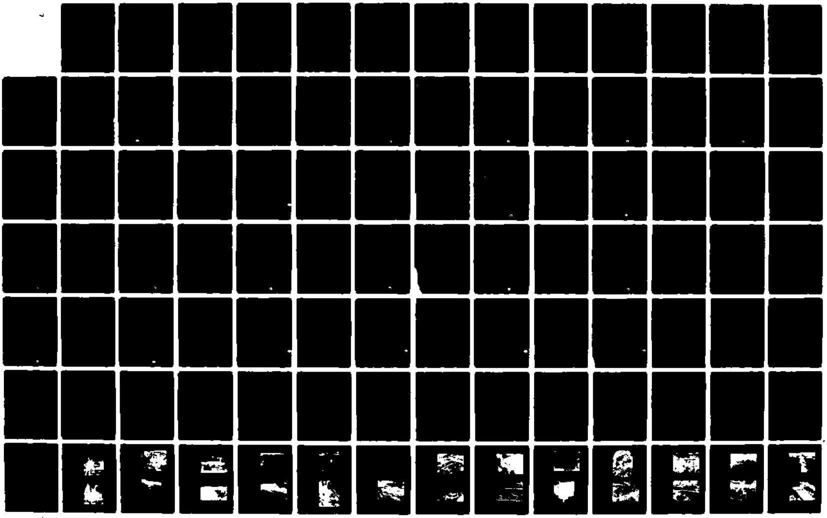


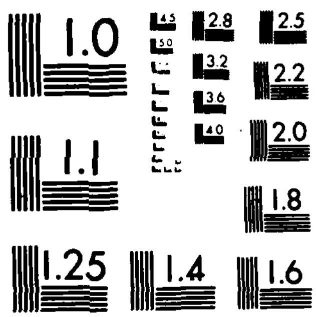
Match Line fig 36
tight S 70° W
Uneven Surface
tight
Bedding Plane
Sta 2+38 D
Sta 2+68 D


pink gypsum nodules
w/softer shale matrix
tight
Sta 2+98 D
Sta 3+28 D
Sta 3+54 D
Sta 3+74 D
Match Line figs 38 & 39
1
2

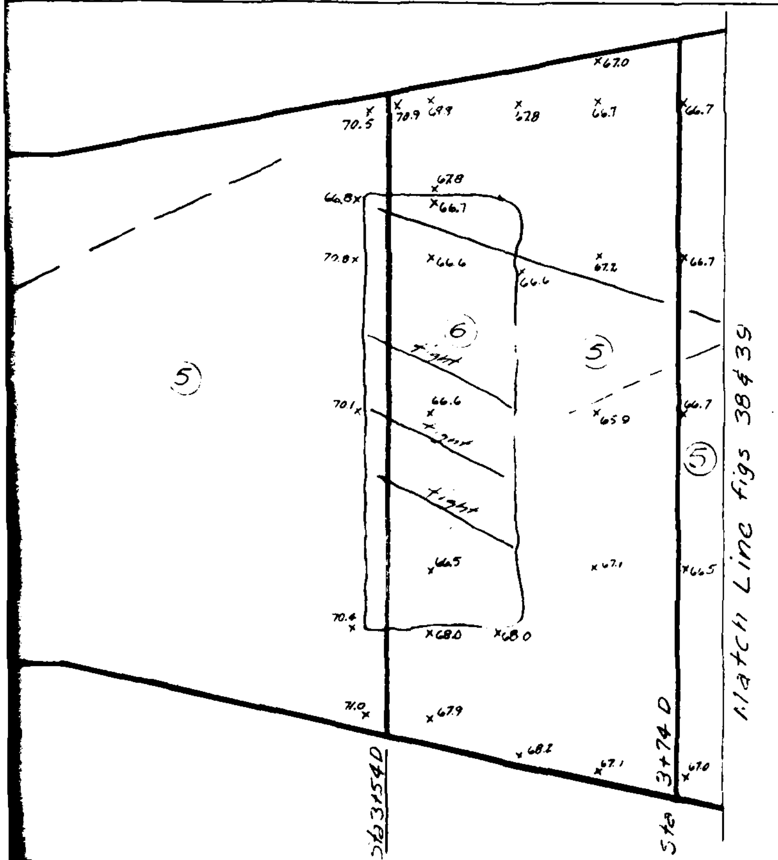
AD-A137 721 MULTIPLE-PURPOSE PROJECT KANSAS RIVER BASIN REPUBLICAN RIVER KANSAS MILFO..(U) CORPS OF ENGINEERS KANSAS CITY MO KANSAS CITY DISTRICT S D MARKWELL ET AL. OCT 83 2/3

UNCLASSIFIED F/G 13/13 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963 A



For notes and legend see Fig. 33.

Scale 6 feet

In 1 sheet

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

OUTLET WORKS
FOUNDATION MAP
STA. 2+08 DOWNSTREAM
TO STA. 3+77 DOWNSTREAM

Sheet No. 1

Scale: as shown

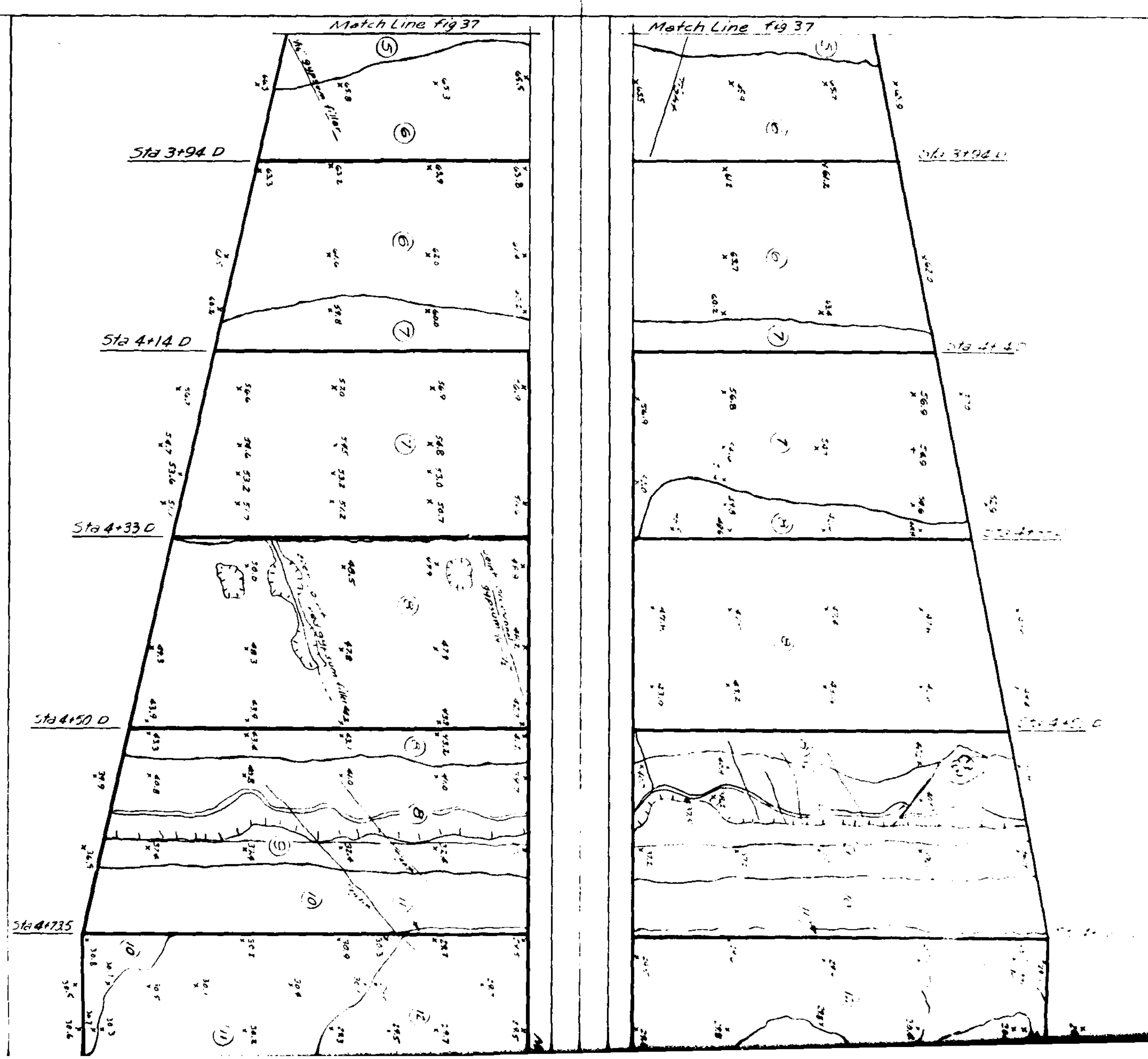
CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1947

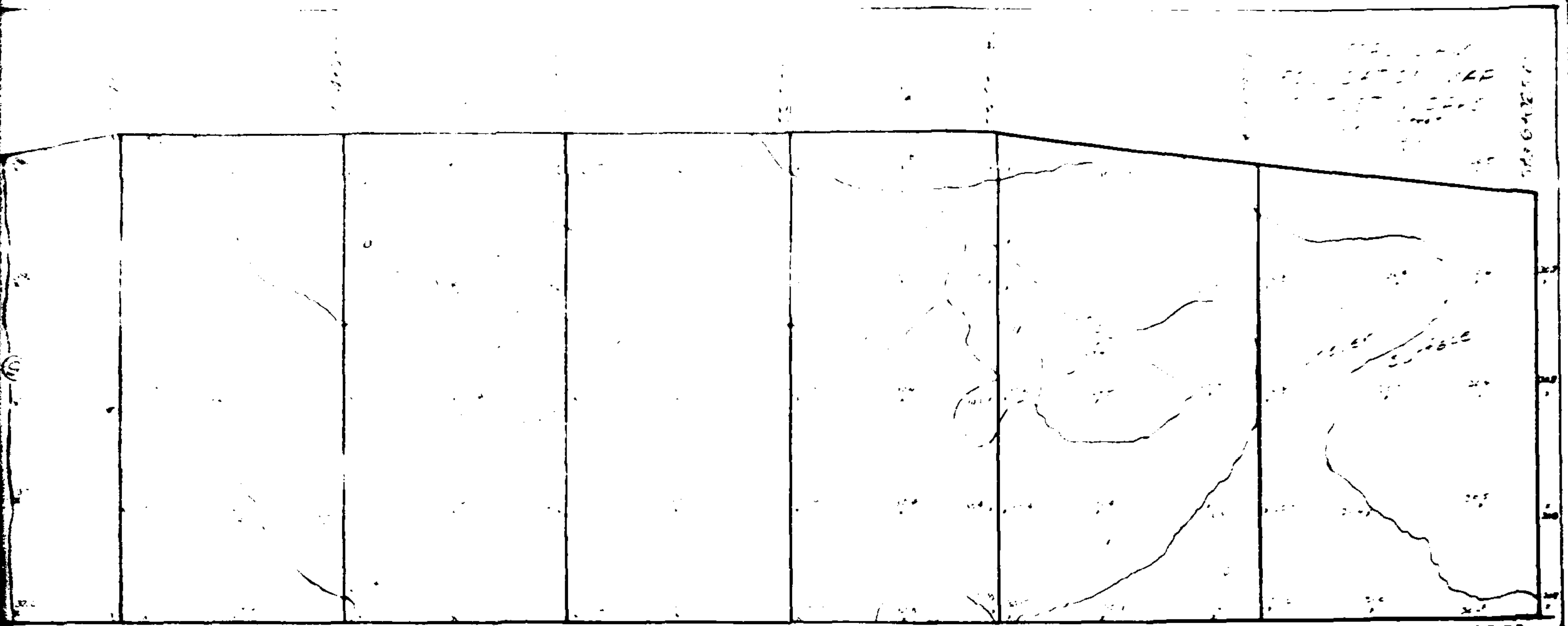
APRIL 1977

FIG. 37

FIGURE 37

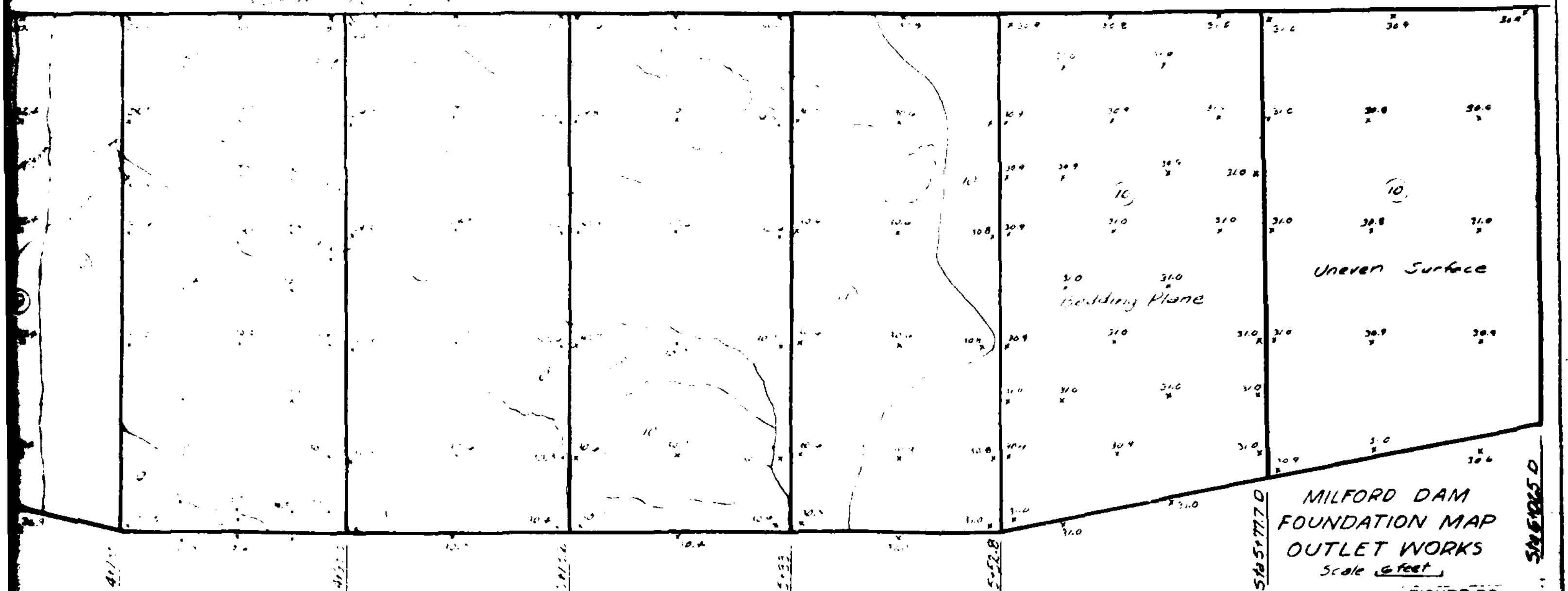


Match Line Fig 37
Match Line Fig 37
Tight
gypsum filler
Sta 3+94 D
Sta 4+14 D
Sta 4+33 D
Sta 4+50 D
Sta 4+73.5



for notes and legend see fig 33

FIGURE 38



for notes and legend see fig 33

FIGURE 39

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT
OUTLET WORKS
FOUNDATION MAP OF
LEFT AND RIGHT HALVES
STA. 3+77 DOWNSTREAM
TO STA. 6+02.5 DOWNSTREAM

In 1 sheet — Sheet No. 1 — Scale: as shown

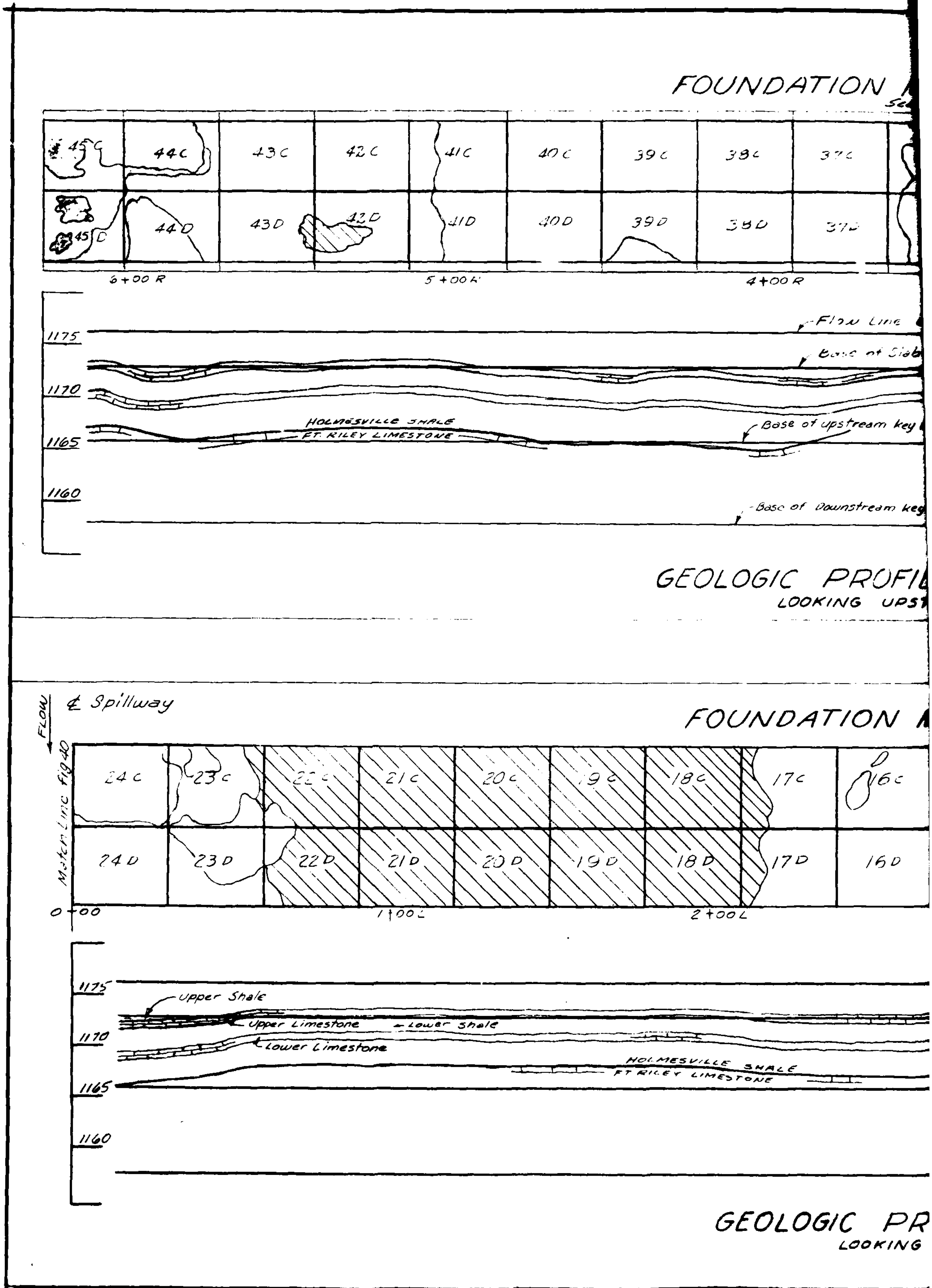
CORPS OF ENGINEERS — U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1948
APRIL 1977

N

2

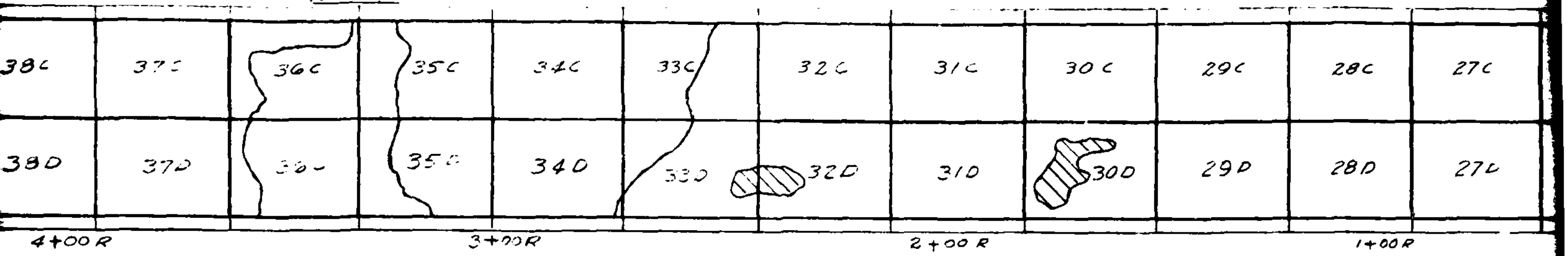
FIGURES 38 & 39

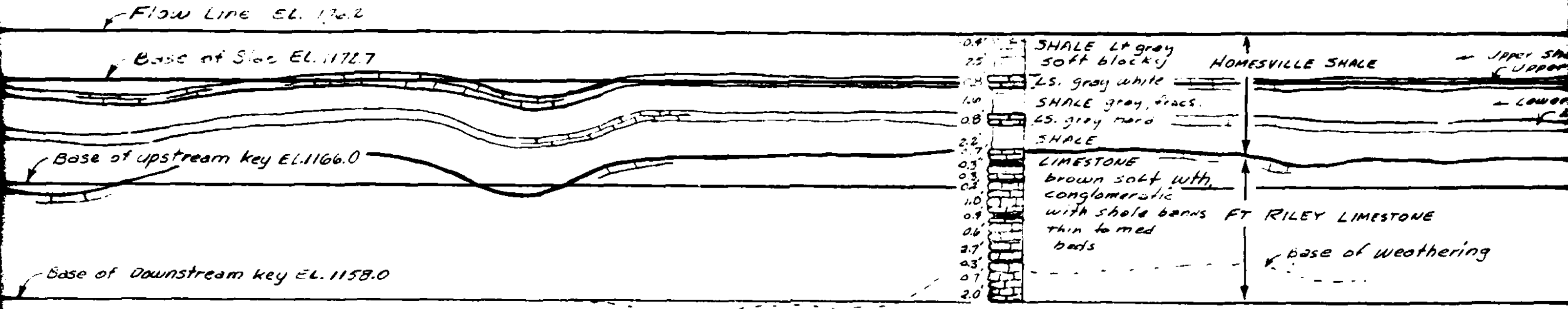


FOUNDATION
45C
44C
43C
42C
41C
40C
39C
38C
37C
45D
44D
43D
42D
41D
40D
39D
38D
37D
6+00 R
5+00 R
4+00 R
1175
1170
1165
1160
Flow Line
Base of Slab
HOLMESVILLE SHALE
FT. RILEY LIMESTONE
Base of upstream key
Base of Downstream key
GEOLOGIC PROFIL
LOOKING UPST
FLOW
℄ Spillway
FOUNDATION
Match Line Fig 40
24C
23C
22C
21C
20C
19C
18C
17C
16C
24D
23D
22D
21D
20D
19D
18D
17D
16D
0+00
1+00L
2+00L
1175
1170
1165
1160
Upper Shale
Upper Limestone
Lower Shale
Lower Limestone
HOLMESVILLE SHALE
FT RILEY LIMESTONE
GEOLOGIC PR
LOOKING

UNDATION MAP SPILLWAY CREST SLAB

Scale 20 feet



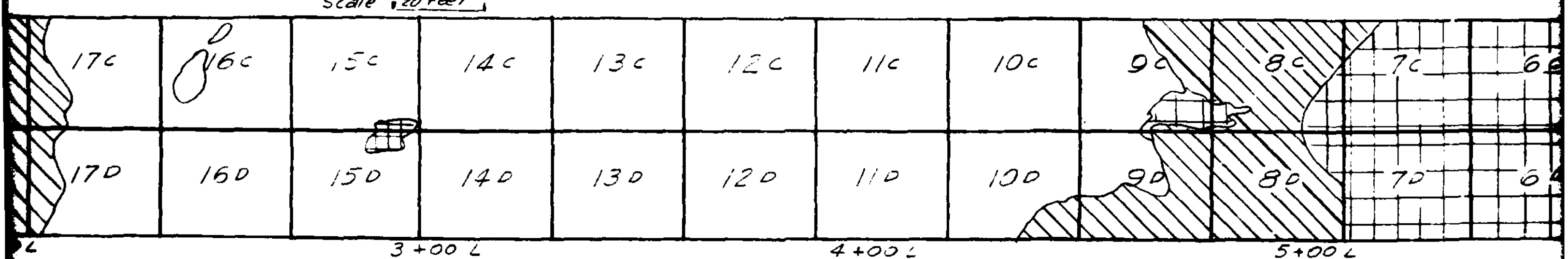


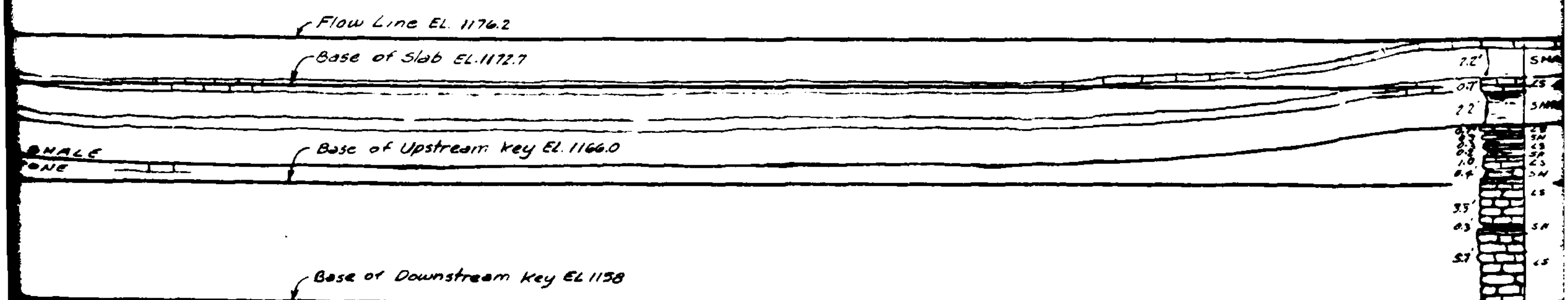
OGIC PROFILE SPILLWAY CREST

LOOKING UPSTREAM

UNDATION MAP SPILLWAY CREST SLAB

Scale 20 feet





EOLOGIC PROFILE SPILLWAY CREST

LOOKING UPSTREAM

1

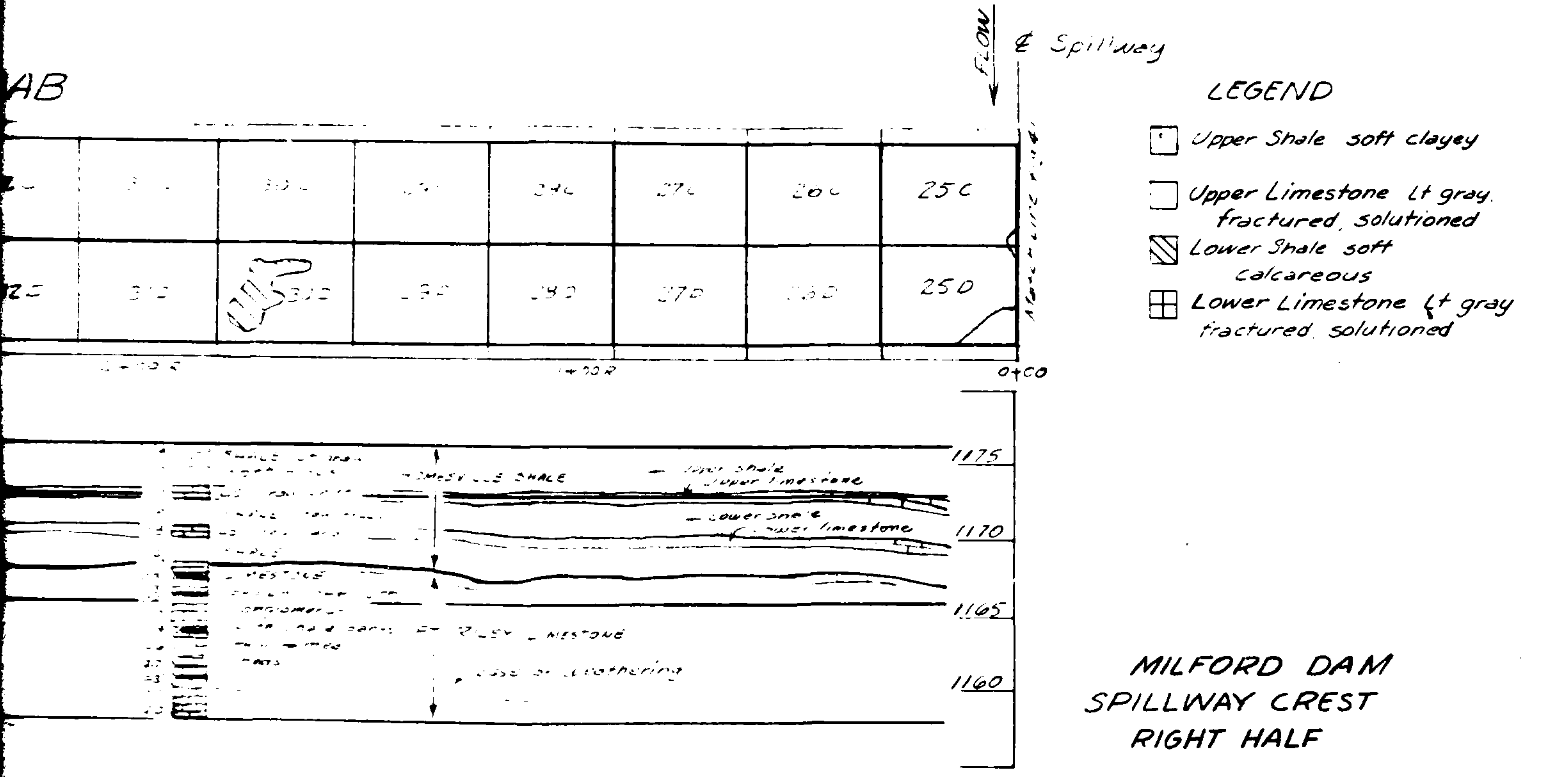
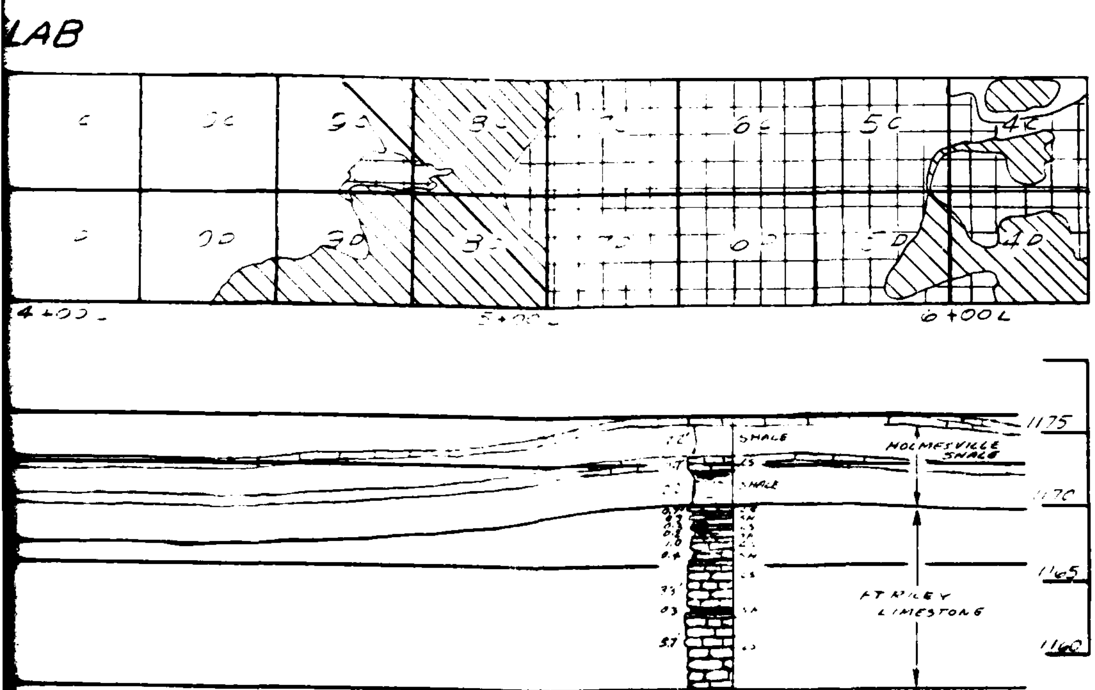


FIGURE 40



LEGEND

- Upper Shale soft clayey
- Upper Limestone Lt gray fractured, solutioned
- Lower Shale, soft calcareous
- Lower Limestone Lt gray fractured, solutioned

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

SPILLWAY SLAB FOUNDATION MAP PLAN AND PROFILE

In 1 sheet | Sheet No. 1 | Scale: as shown

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1949

APRIL 1977

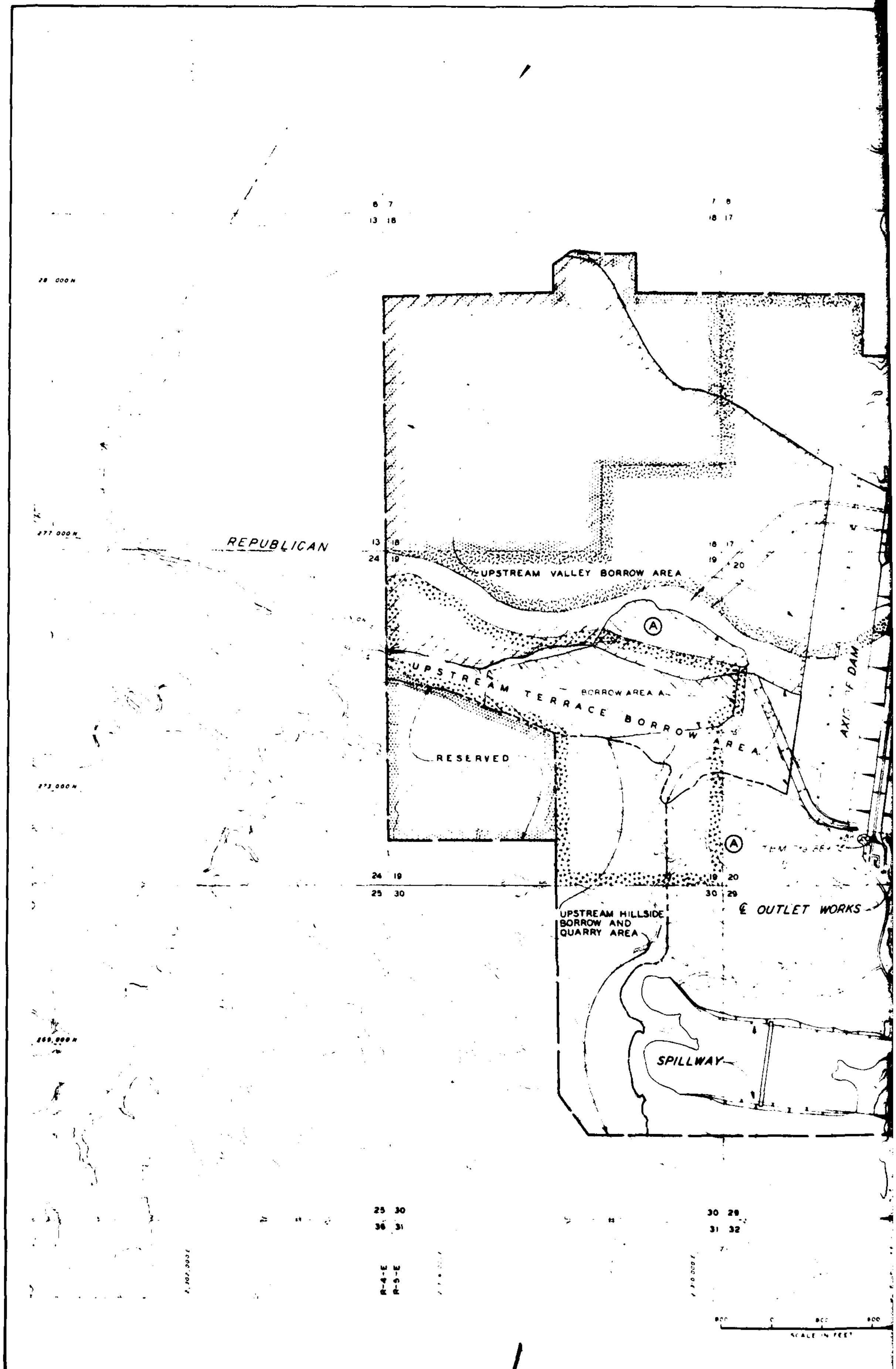
FIGURE 41

FIGURES 40 & 4

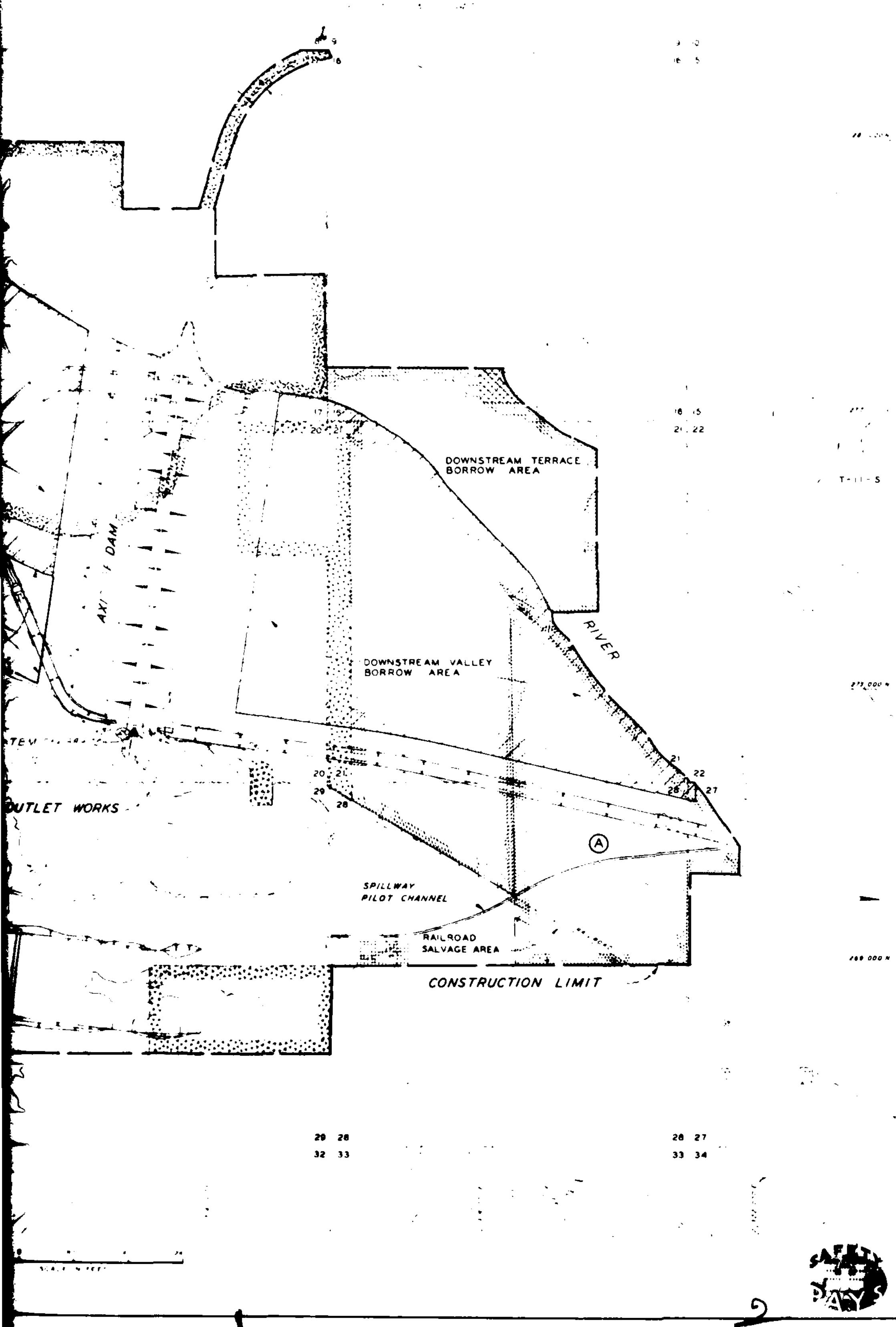
DRAWINGS

DRAWINGS

CORPS OF ENGINEERS



U S ARMY



RIGHT-OF-WAY CODE

NOT AVAILABLE UNTIL JUNE 1, 1962
NOT AVAILABLE UNTIL JUNE 20, 1962
NOT AVAILABLE UNTIL JULY 1, 1962
NOT AVAILABLE UNTIL JULY 15, 1962
NOT AVAILABLE UNTIL DECEMBER 31, 1962
CROPS RESERVED UNTIL JULY 15, 1962

RECORD DRAWING
DECEMBER 1966
CONTRACT NO DA 23 028 CIVENG 62 739

SYM	DESCRIPTION	DATE	APP'D
A	[illegible]	[illegible]	

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

GENERAL PLAN

In 141 sheets — Sheet No. 3 — Scale: as shown

U S ARMY ENGINEER DISTRICT
KANSAS CITY

KANSAS CITY, MO
APRIL 1962

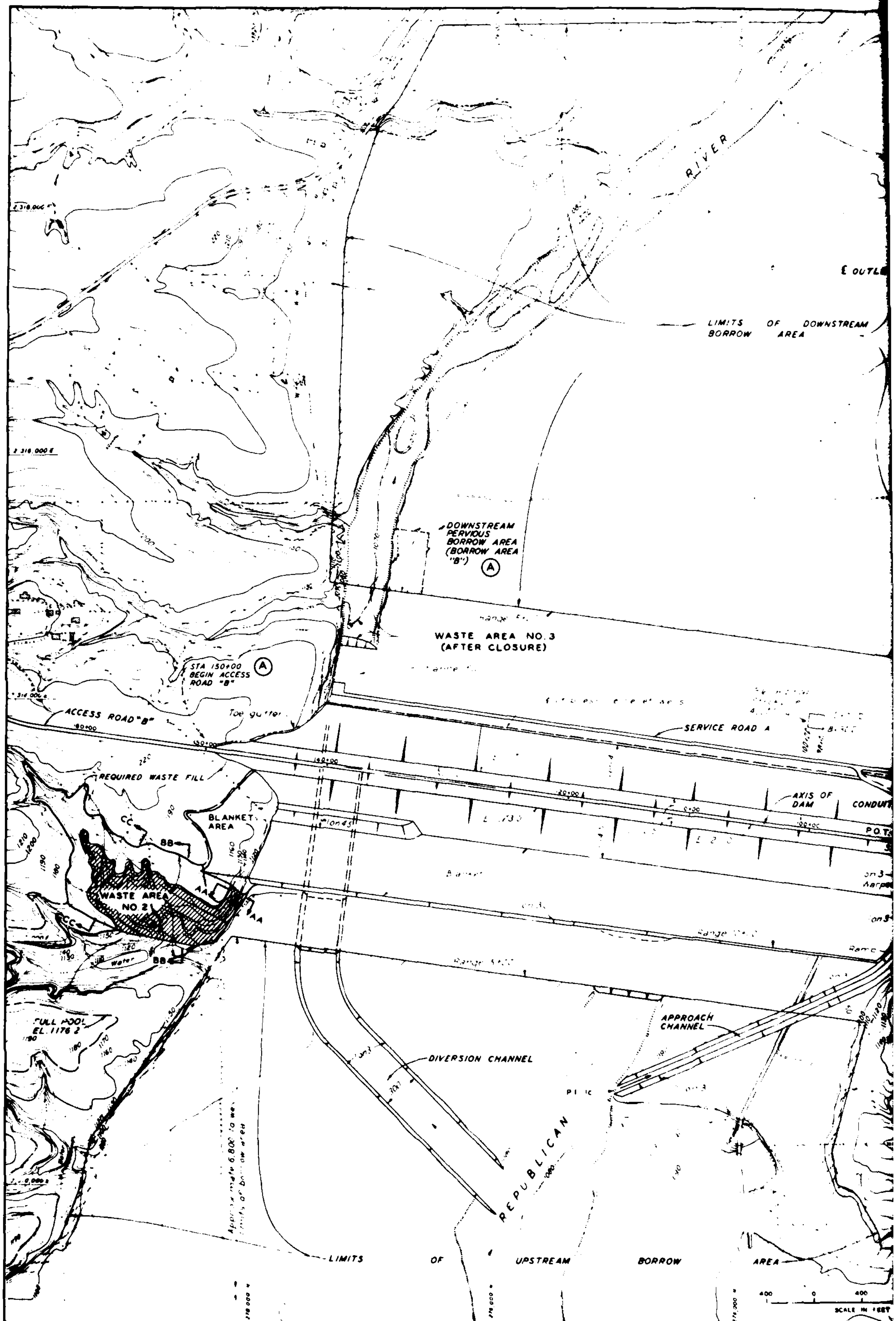
Submitted: CHIEF STRUCTURAL SECTION
Recommended: CHIEF DESIGN BRANCH
Approved: CHIEF ENGINEERING DIVISION

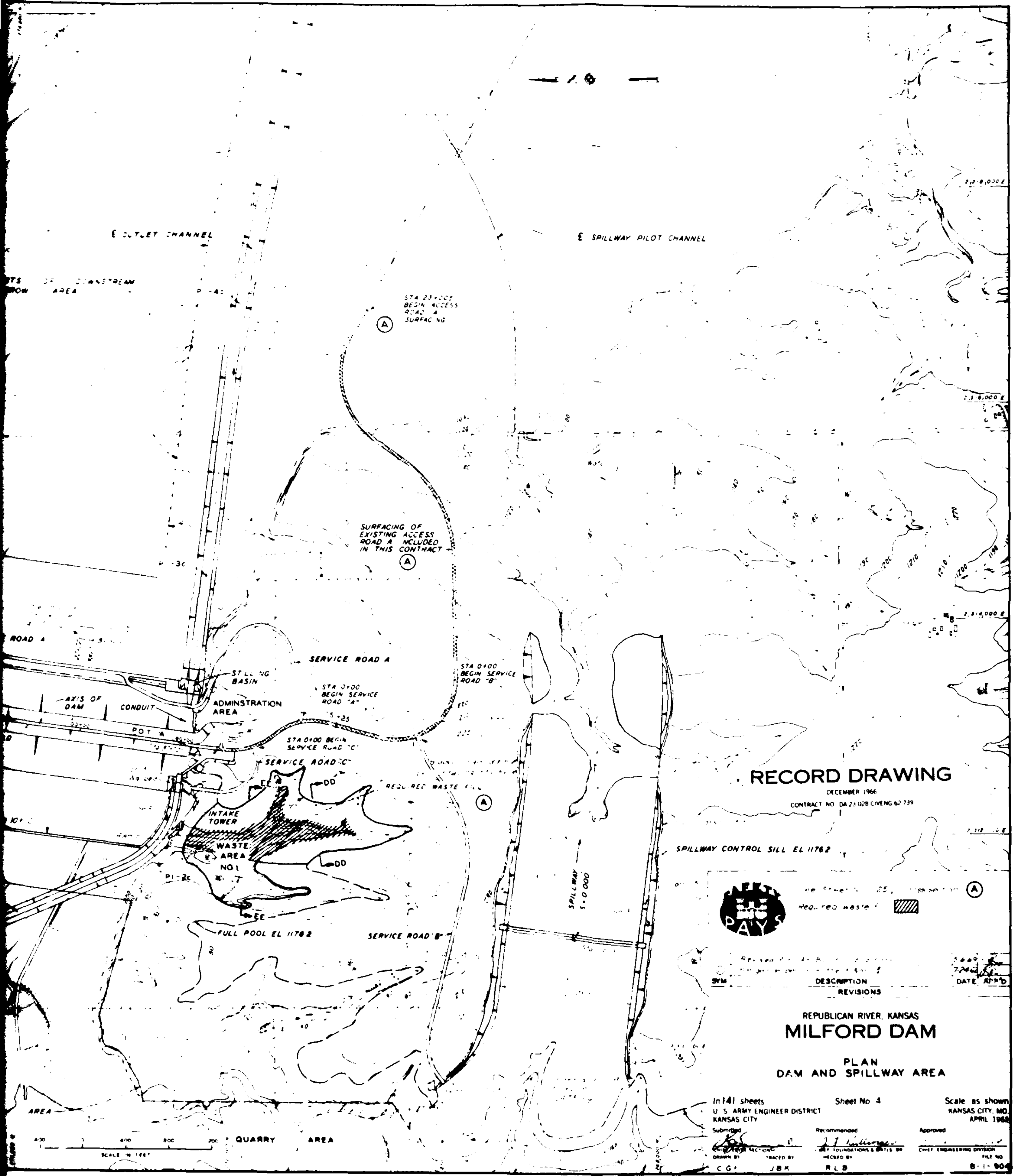
DRAWN BY J A ? — TRACED BY C.E.W — CHECKED BY M M R

FILE NO B-1-803

PLATE NO. I

CORPS OF ENGINEERS



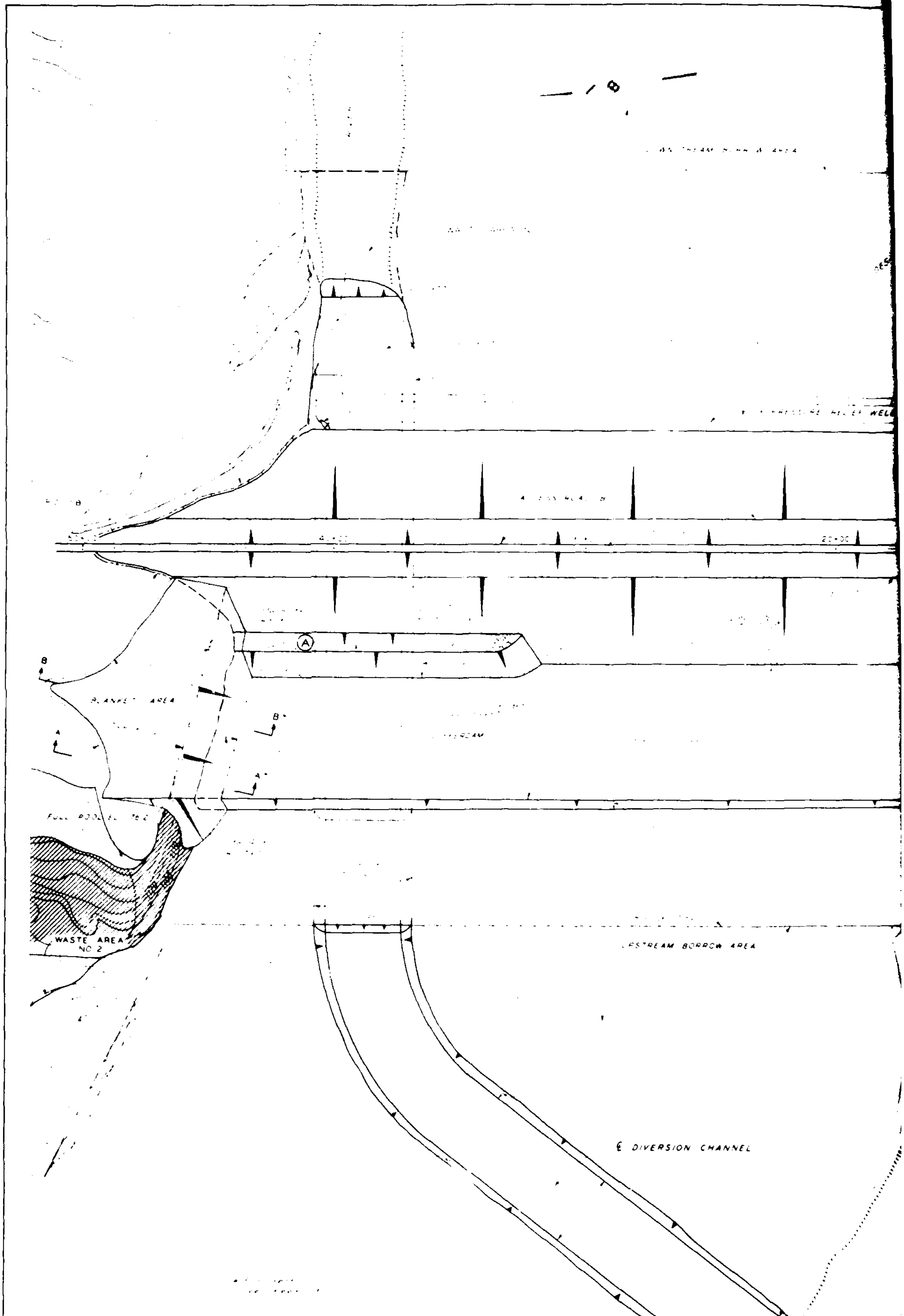


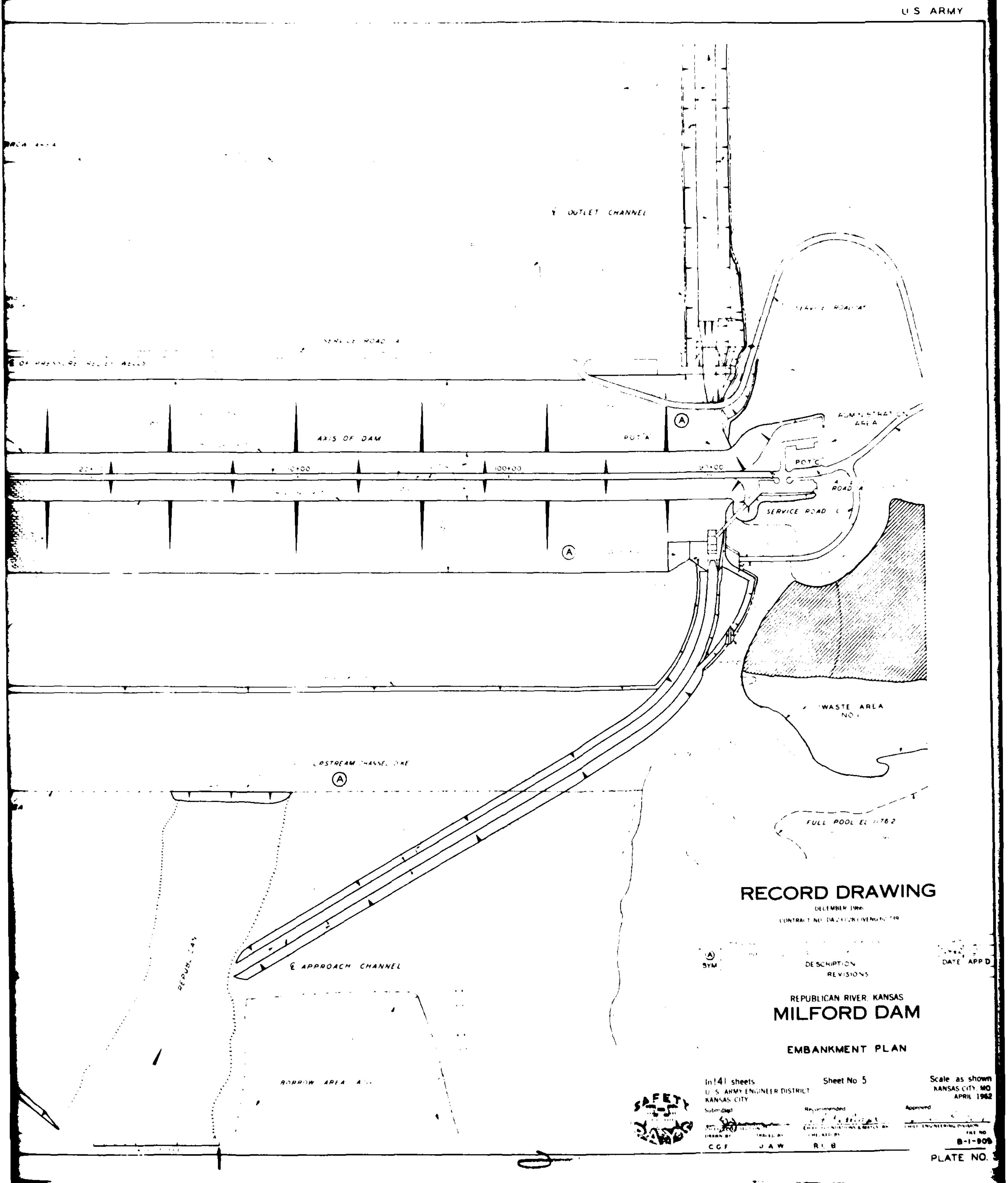
OUTLET CHANNEL
SPILLWAY PILOT CHANNEL
STA 23+00 BEGIN ACCESS ROAD A SURFACING
SURFACING OF EXISTING ACCESS ROAD A INCLUDED IN THIS CONTRACT
ROAD A
SERVICE ROAD A
STILLING BASIN
AXIS OF DAM
CONDUIT
ADMINSTRATION AREA
STA 0+00 BEGIN SERVICE ROAD "B"
STA 0+00 BEGIN SERVICE ROAD "A"
STA 0+00 BEGIN SERVICE ROAD "C"
SERVICE ROAD "C"
REQUIRED WASTE FILL
INTAKE TOWER
WASTE AREA NO. 1
FULL POOL EL 1176.2
SERVICE ROAD "B"
SPILLWAY S 0+000
SPILLWAY CONTROL SILL EL 1176.2
QUARRY AREA
SCALE IN FEET
RECORD DRAWING
DECEMBER 1966
CONTRACT NO. DA 23 028 CIVENG 62 739
SAFETY PAYS
Required waste fill
SYM
DESCRIPTION
DATE
APP'D
REVISIONS
REPUBLICAN RIVER, KANSAS
MILFORD DAM
PLAN
DAM AND SPILLWAY AREA
In 141 sheets
Sheet No. 4
Scale as shown
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY
KANSAS CITY, MO.
APRIL 1962
Submitted
Recommended
Approved
DRAWN BY
TRACED BY
CHECKED BY
CHIEF, FOUNDATIONS & MATLS. BR.
CHIEF, ENGINEERING DIVISION
FILE NO.
C G I
J B K
R L B

1

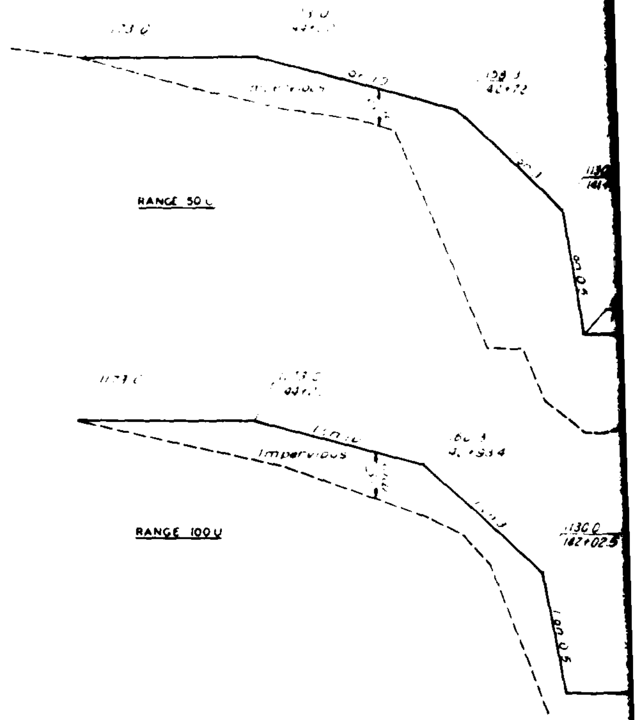
2

PLATE NO. 2

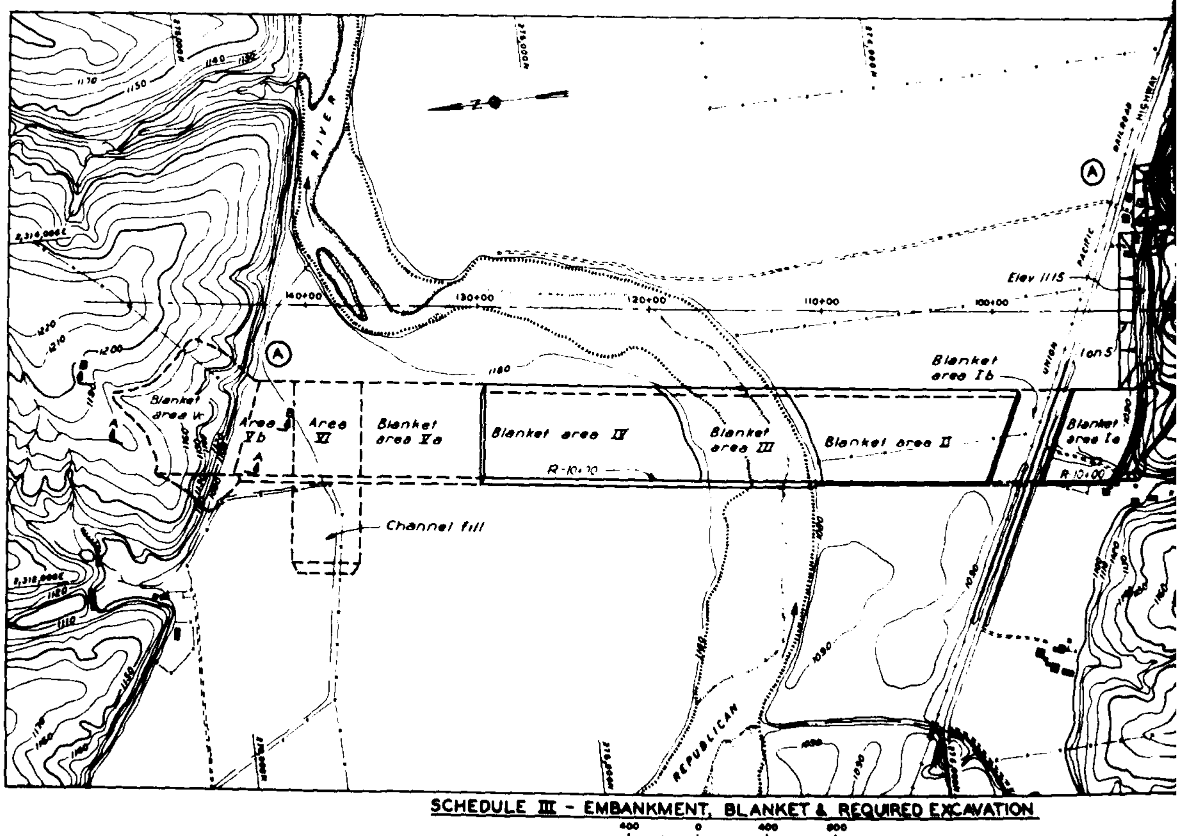

BLANKET AREA
WASTE AREA
NO 2
UPSTREAM BORROW AREA
℄ DIVERSION CHANNEL



U S ARMY
OUTLET CHANNEL
SERVICE ROAD "A"
SERVICE ROAD A
AXIS OF DAM
ADMINISTRATION AREA
100+00
SERVICE ROAD C
WASTE AREA NO 1
UPSTREAM CHANNEL DIKE
FULL POOL EL 1176.2
APPROACH CHANNEL
BORROW AREA
RECORD DRAWING
DECEMBER 1966
DESCRIPTION
REVISIONS
SYM
DATE
APP'D
REPUBLICAN RIVER, KANSAS
MILFORD DAM
EMBANKMENT PLAN
In 141 sheets
Sheet No. 5
Scale as shown
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY
KANSAS CITY, MO
APRIL 1962
Submitted
Recommended
Approved
SAFETY
C G F
J A W
R L B
B-1-905
PLATE NO.

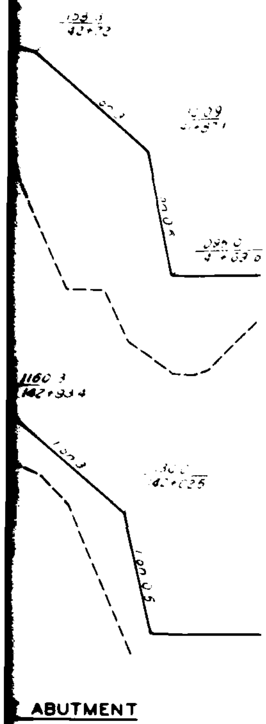


IMPERVIOUS BLANKET LEFT ABUTMENT



SCHEDULE III - EMBANKMENT, BLANKET & REQUIRED EXCAVATION

400 0 400 800
SCALE IN FEET



SCHEDULING

Right Abutment Area And Blanket Areas

Dates that right abutment area and blanket areas Ia, II, III and IV are available to Stage III Contractor are given in the specifications

(A) The Schedule II Contractor may place the impervious blanket in area IV prior to first stage diversion. Immediately after first stage diversion, the impervious blanket shall be completed for area IV

(A) Schedule III Contractor shall construct blanket areas Ia and II complete, and finish construction of areas III and V to the extent shale and limestone are available from required Outlet Works excavation

Schedule II Contractor shall complete the upstream blanket in all blanket areas after Schedule III blanket operation is completed

Blanket area VI and upstream channel fill in diversion channel are to be placed at the time of closure. Areas Vb, Vc may be deferred until this time

Blanket area Ib shall be made only after the railroad right-of-way is available. For date railroad right-of-way is available, see specifications.

(A) Schedule III work areas are shown shaded

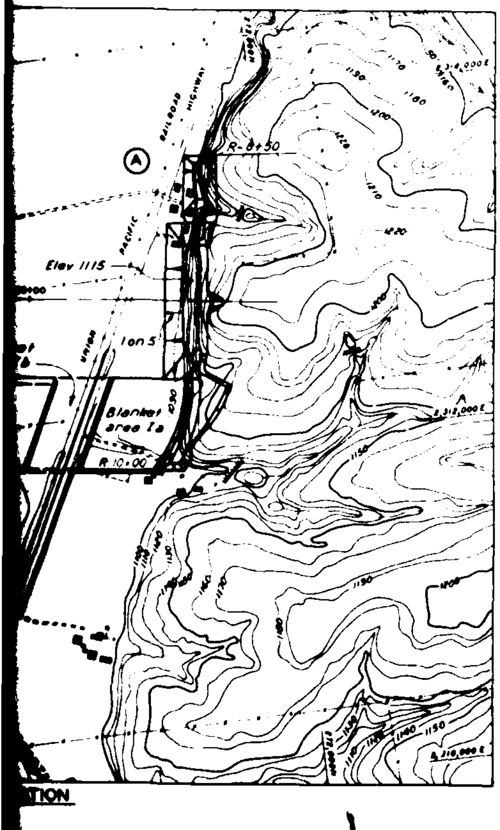
SPILLWAY

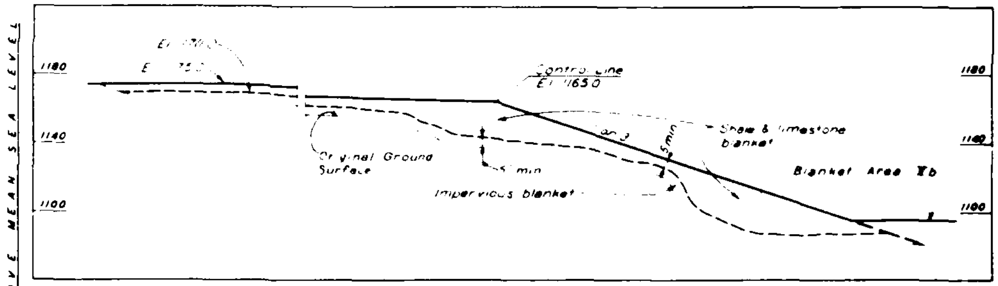
Spillway schedules not shown, see Sheet No 109

GENERAL NOTES

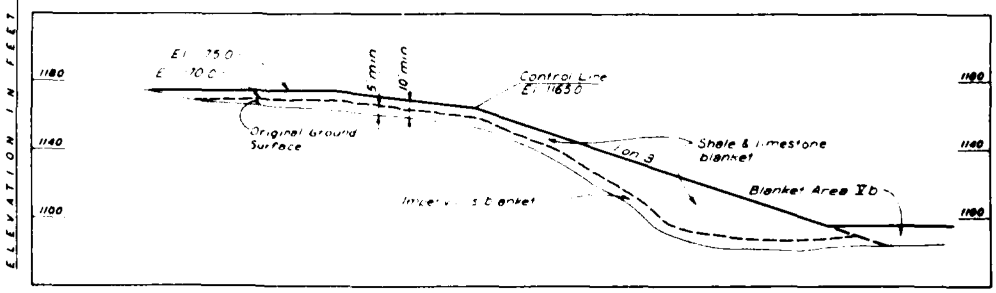
The area use schedule is furnished as general information to the Contractor; it is not intended to imply that the Contractors mentioned and others may not perform other work in the designated areas or shall not perform work or have access to other areas within which work is required under the specifications

Schedule II Contractor shall request construction areas as covered in the specifications.





SECTION B-B



SECTION A-A

SECTIONS THRU BLANKET AREA VC

REPUBLICAN RIVER, KANSAS

MILFORD DAM

SCHEDULED WORK AREAS

RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA 23 028 CIVENG 62 739

SYM.	DESCRIPTION	DATE	APP'D
	Revised for As Built conditions	5-6-69	
(A)	Changed as per Amendment No. 1	7-24-62	
	REVISIONS		

In 141 sheets Sheet No. 6 Scale: as shown

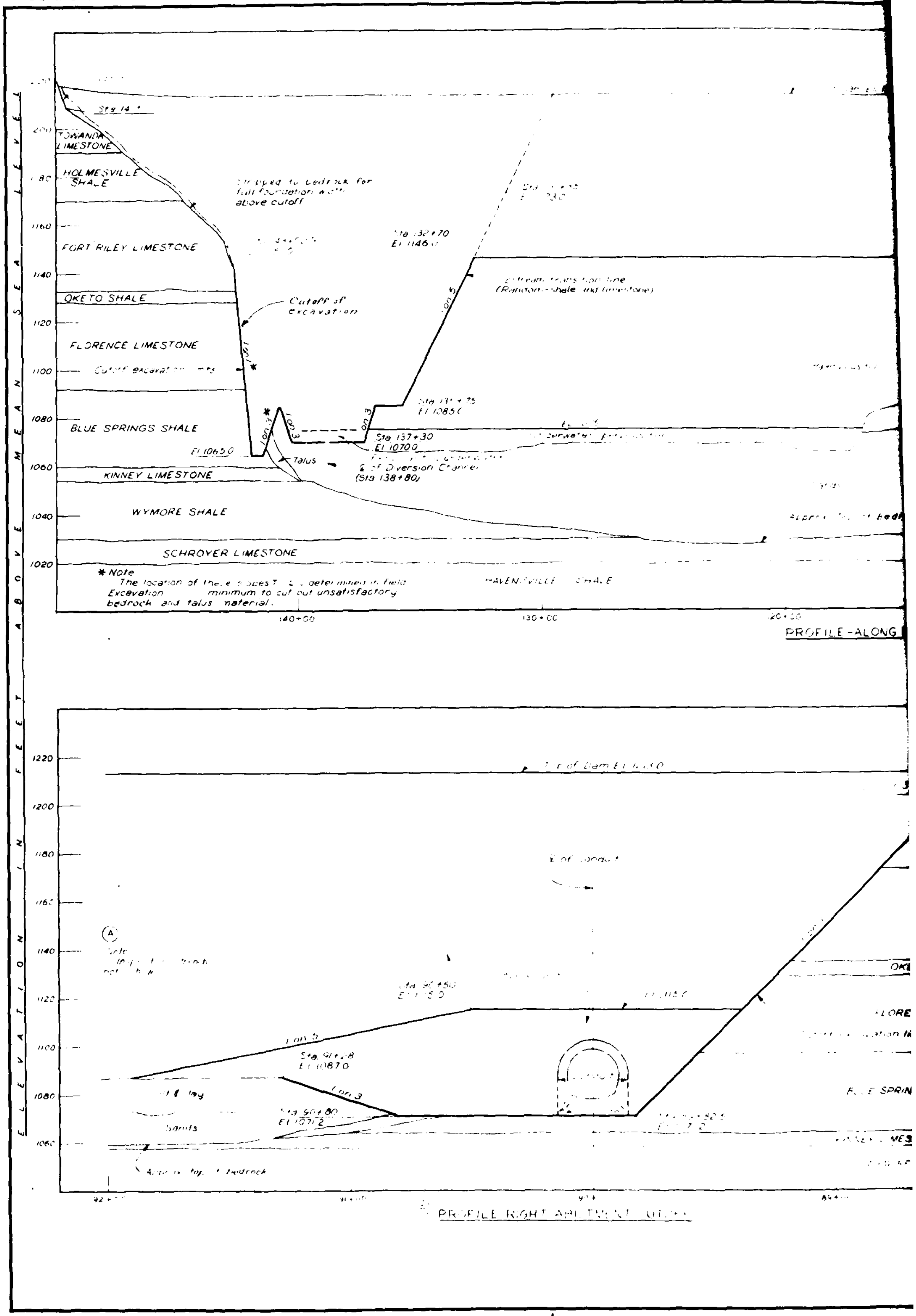
U. S. ARMY ENGINEER DISTRICT, KANSAS CITY — KANSAS CITY, MO. APRIL 196

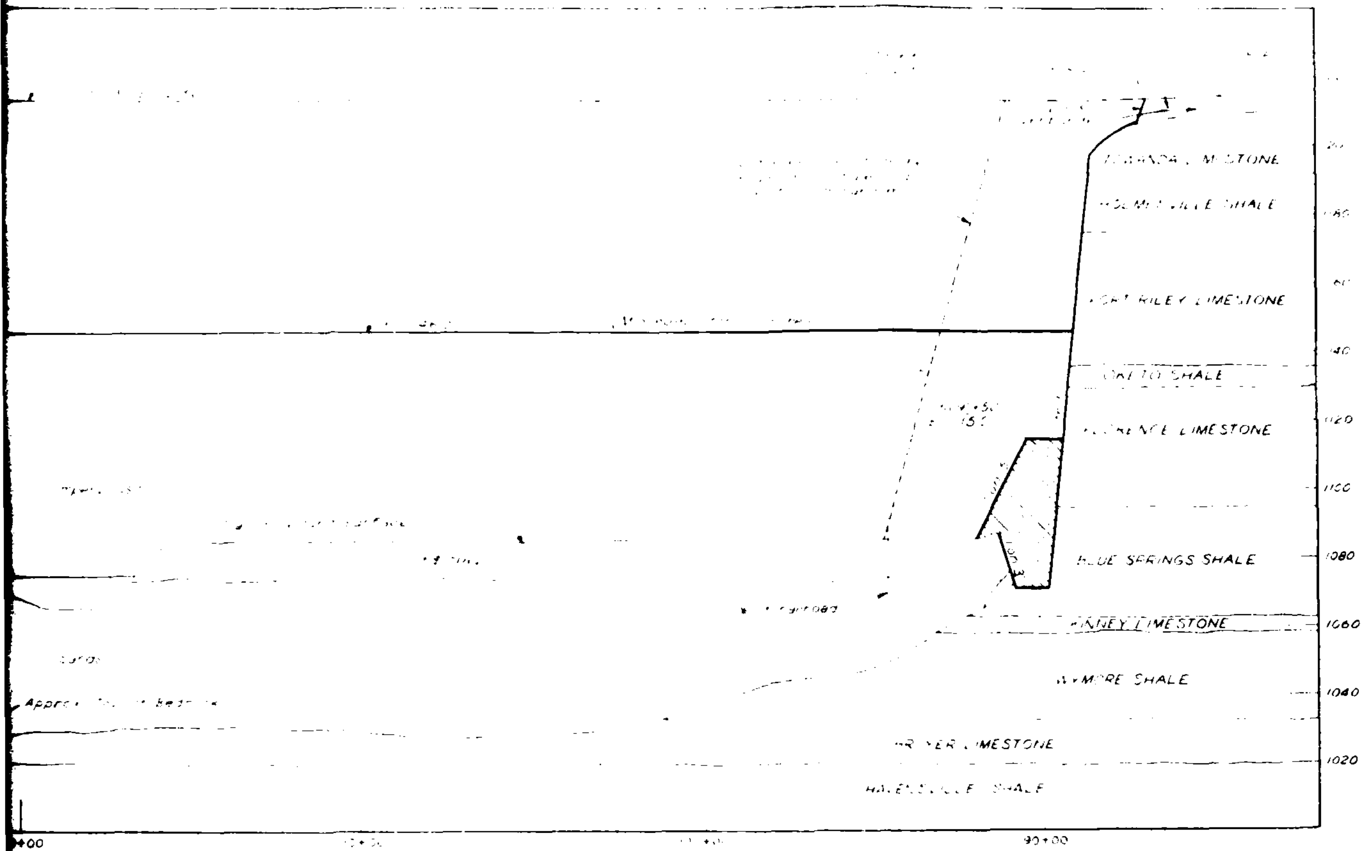
Submitted: Chief, Design Section — Recommended: Chief, Foundations & Materials Br. — Approved: Chief, Engineering Division

Drawn by C.G.F. — Traced by C.E.M. — Checked by R.L.B.

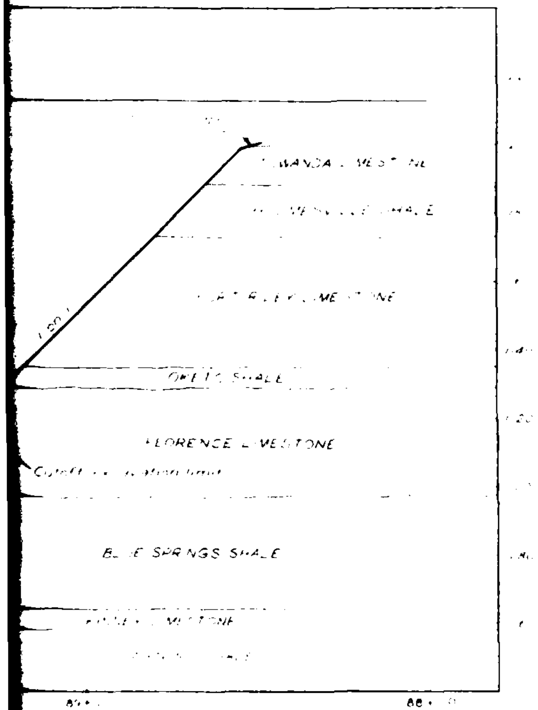
PLATE NO.

CORPS OF ENGINEERS





PROFILE-ALONG DAM AXIS



NOTES:
Left abutment excavation plan shown on Sheet No. 8
For grouting details, see Sheet No. 14

RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA-23-028-CIVENG-62-730

SYM	DESCRIPTION	DATE	APP'D
	Revised for As Built conditions	5-4-69	
Ⓐ	Changed as per Amendment No. 1	7-24-62	

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

PROFILES DAM AXIS

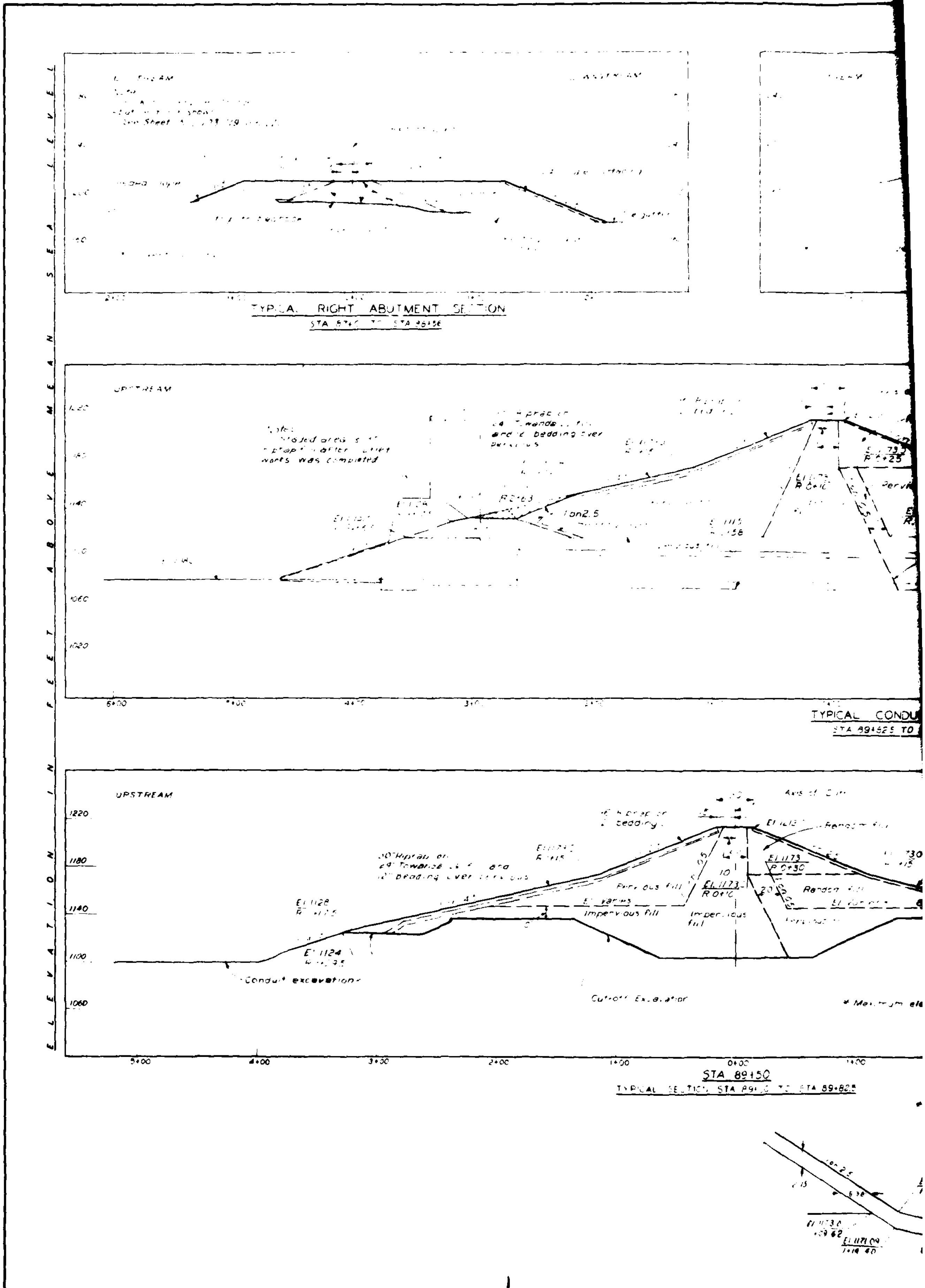
In 141 sheets — Sheet No. 7 — Scale: as shown

U. S. ARMY ENGINEER DISTRICT, KANSAS CITY — KANSAS CITY, MO, APRIL 1962

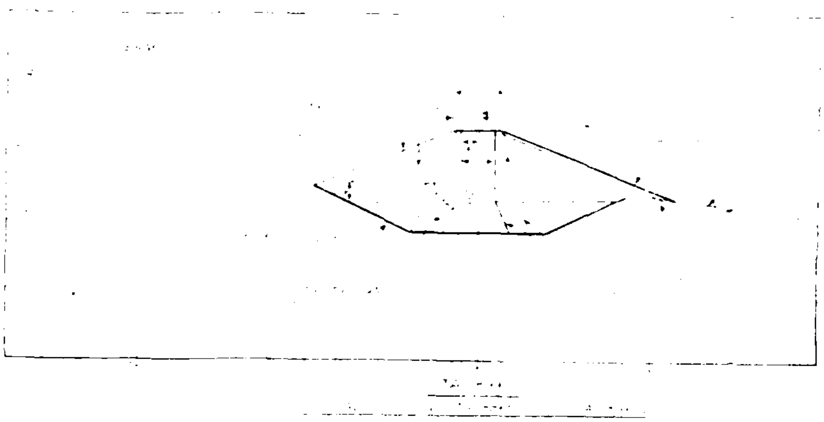
Submitted: CHIEF, DESIGN SECTIONS — Recommended: CHIEF, FOUNDATIONS & MATLS. BR. — Approved: CHIEF, ENGINEERING DIVISION

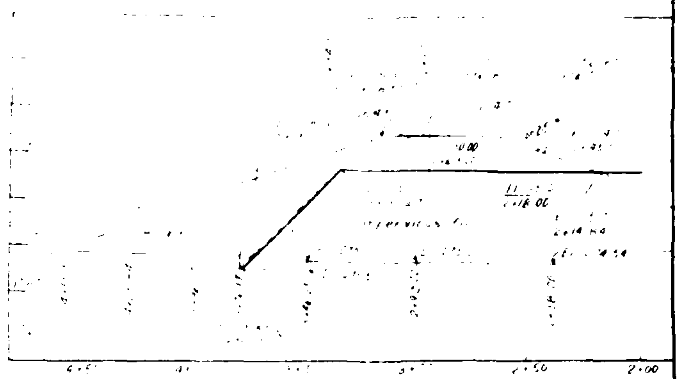
DRAWN BY C.C. — TRACED BY R.F.M. — CHECKED BY R.L.B. — FILE NO. 8-1 907

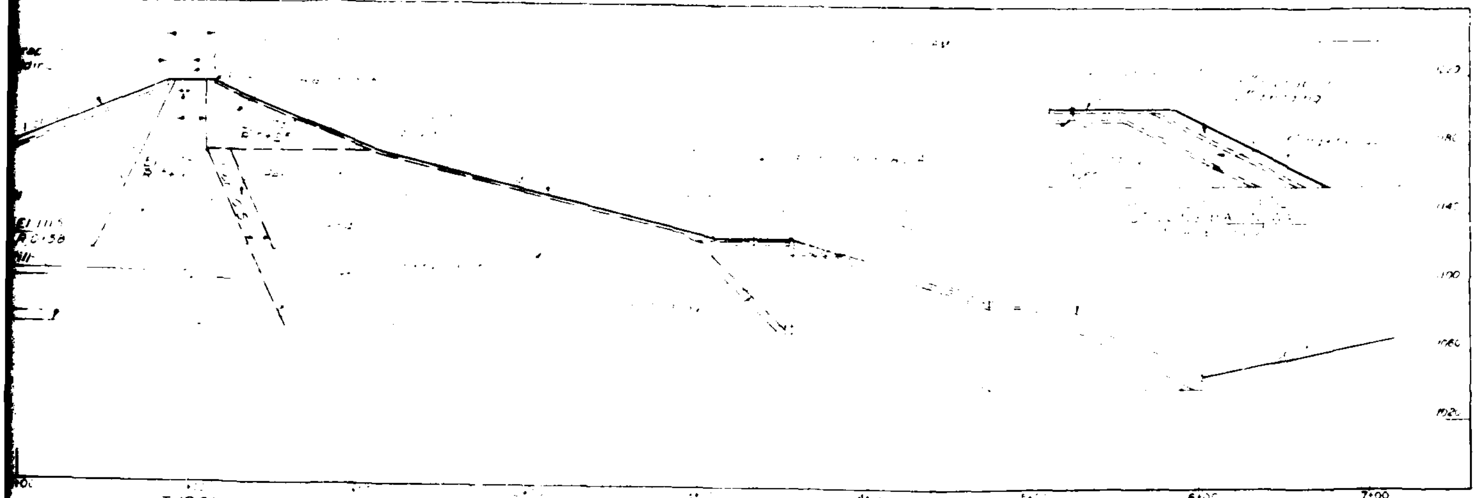
CORPS OF ENGINEERS



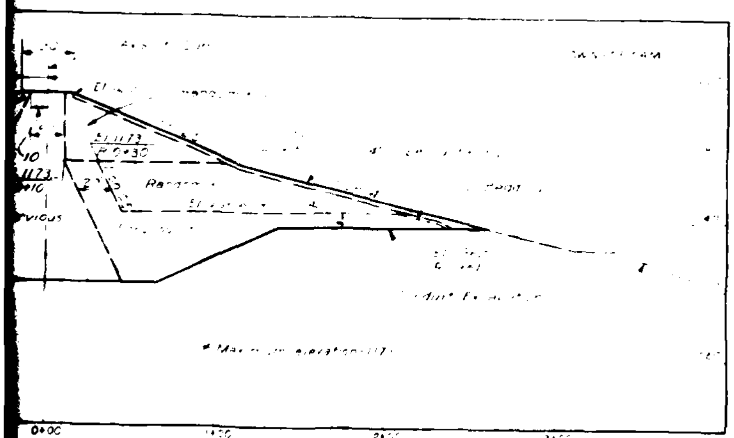
U S ARMY

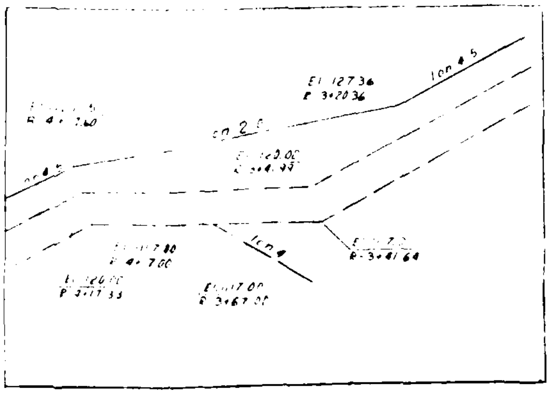






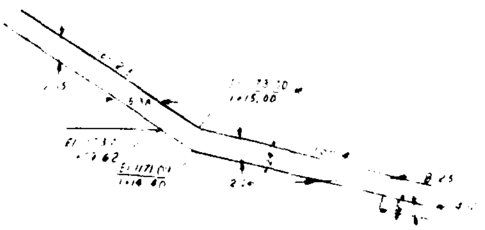
TYPICAL CONDUIT SECTION





NOTES:
For top of dam surfacing detail, see Sheet No. 12.
For vertical curve "A" data, see Sheet No. 113

* Distances apply between vertical curves only. Sta 89+35 to ...



	Revised for "As Built" conditions	5-6-69	
Ⓐ	Changed as per Amendment No. 1	7-24-62	
SYM.	DESCRIPTION	DATE	APP'D.
	REVISIONS		

REPUBLICAN RIVER, KANSAS
MILFORD DAM
EMBANKMENT SECTIONS

RECORD DRAWING
DECEMBER 1966
CONTRACT NO. DA-23-028-CIVENG-62-739

In 141 sheets — Sheet No. 8 — Scale: as shown
U. S. ARMY ENGINEER DISTRICT, KANSAS CITY — KANSAS CITY, MO. APRIL 1962

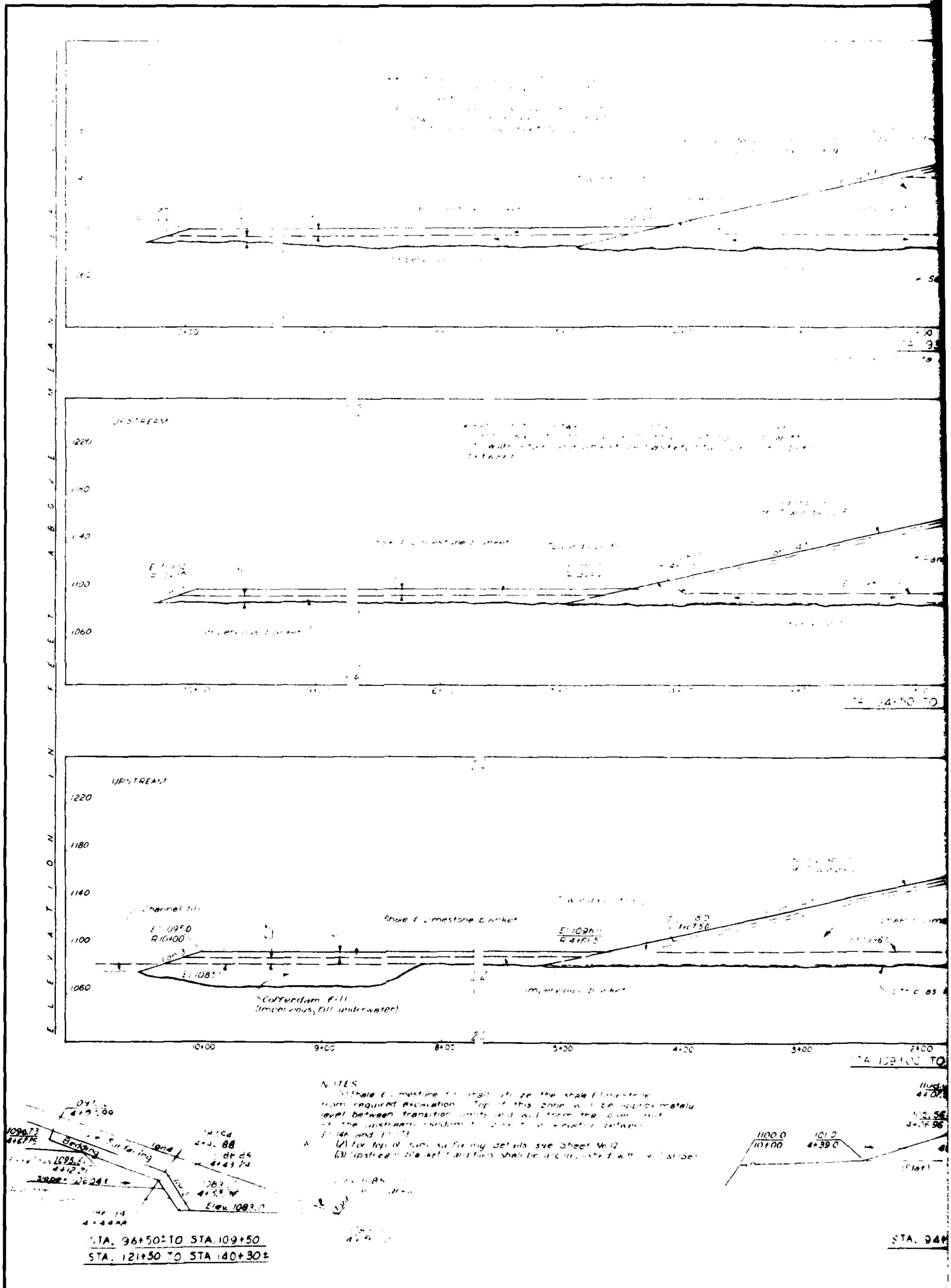
Submitted: CHIEF, DESIGN SECTION — Recommended: J. J. Kedlinger, CHIEF, FOUNDATIONS & MATERIALS BR. — Approved: CHIEF, ENGINEERING DIVISION

DRAWN BY C.G.F. — TRACED BY J.R.P. — CHECKED BY R.L.B. — FILE NO. B-1-908

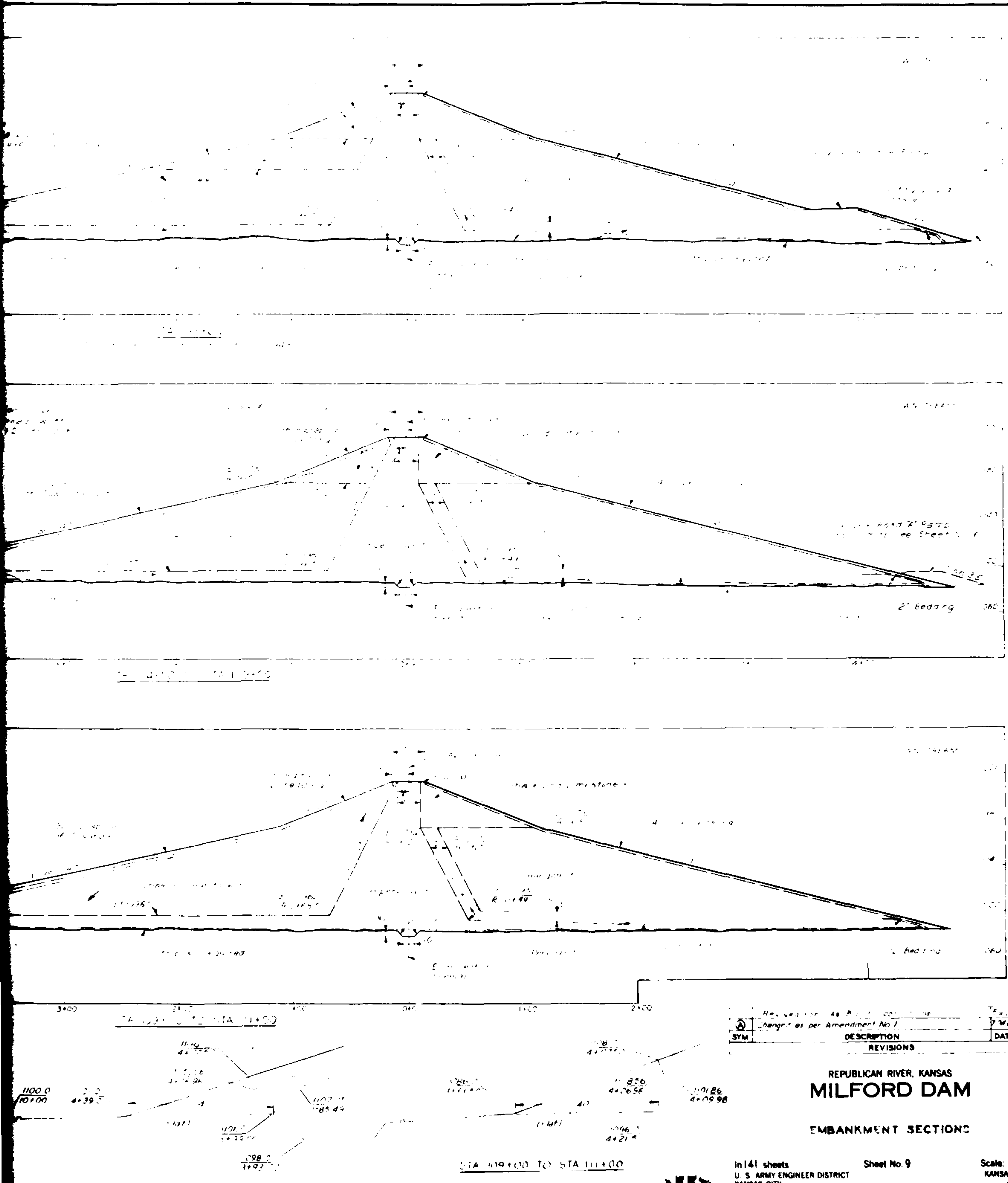
PLATE NO. 6

SAFETY PAYS

1 2



UPSTREAM
1220
1180
1140
1100
1060
Channel fill
Shale & Limestone blanket
Cofferdam fill
(Impervious; fill underwater)
Impervious blanket
10+00
9+00
8+00
5+00
4+00
3+00
2+00
NOTES
(2) For top of ... surfacing details see Sheet No. 12
Bedding
Elev. 1083.0
STA. 96+50± TO STA. 109+50
STA. 121+50 TO STA. 140+30±



STA 109+00 TO STA 111+00

STA. 94+50 TO STA 109+00

SYM	DESCRIPTION	DATE	APP'D
	Revised for As Built conditions		
A	Changes as per Amendment No 1		

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

EMBANKMENT SECTIONS

In 141 sheets — Sheet No. 9 — Scale: as shown

U. S. ARMY ENGINEER DISTRICT KANSAS CITY — KANSAS CITY, MO APRIL 1962

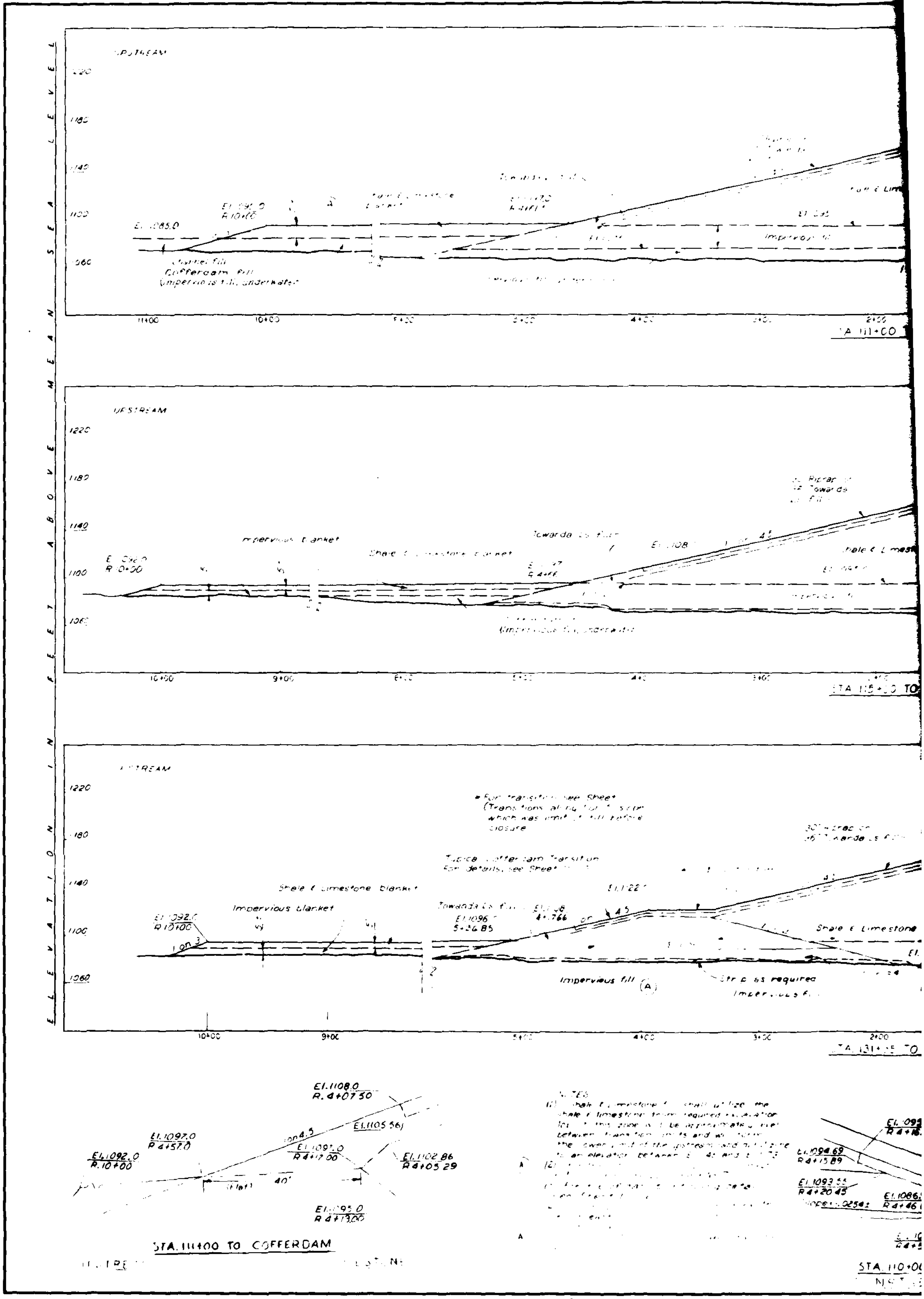
Submitted: CHIEF, DESIGN SECTION — Recommended: J. F. Redlinger, CHIEF, FOUNDATIONS & MATLS BR — Approved: CHIEF, ENGINEERING DIVISION

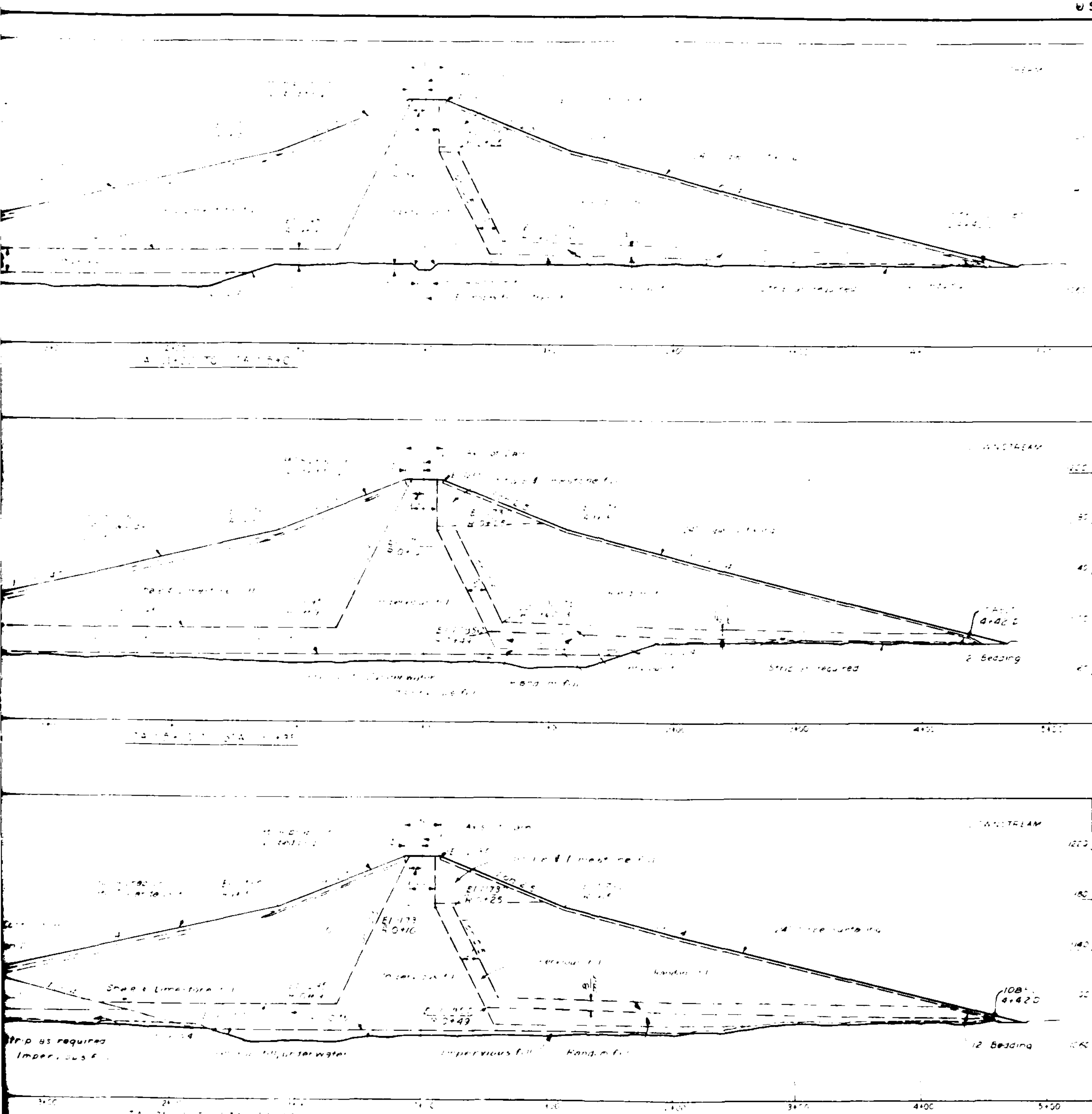
DRAWN BY CCS — TRACED BY JRP — CHECKED BY R.L.B.

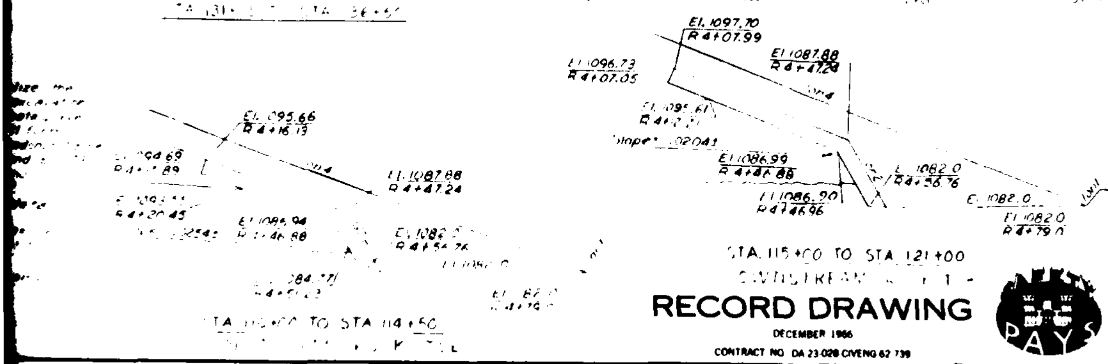
RECORD DRAWING

DECEMBER 1966

CONTRACT NO DA-23-028-CIVENG-62-739


ELEVATION IN FEET ABOVE MEAN SEA LEVEL
UPSTREAM
1220
1180
1140
1100
1060
El. 1085.0
Channel fill
Cofferdam fill
(Impervious fill, underwater)
11+00
10+00
9+00
8+00
7+00
6+00
5+00
4+00
3+00
2+00
STA. 111+00 T
Impervious blanket
Shale & limestone blanket
Towanda Ls. fill
Shale & Limestone
(Impervious fill, underwater)
STA. 115+00 TO
Impervious blanket
Shale & Limestone blanket
El. 1092.0
R 10+00
1 on 3
El. 1096.0
5+26.85
Typical cofferdam transition
For details, see Sheet
El. 1122.0
Impervious fill
(A)
Strip as required
Impervious fill
STA. 131+25 TO
El. 1108.0
R. 4+07.50
El. 1105.56
El. 1097.0
R 4+57.0
El. 1092.0
R. 10+00
1 on 4.5
El. 1097.0
R 4+17.00
El. 1102.86
R 4+05.29
(Flat)
40'
El. 1095.0
R 4+13.00
STA. 111+00 TO COFFERDAM
NOTES
El. 1094.69
R 4+15.89
El. 1093.55
R 4+20.45
El. 1086
R 4+46
STA. 110+00





	Revised for As Built conditions		
A	Changed as per amendment Nos.		
SYM	DESCRIPTION	DATE	APP D.
	REVISIONS		

RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA 23-028 CIVENG 62 739

REPUBLICAN RIVER, KANSAS

MILFORD DAM

EMBANKMENT SECTIONS

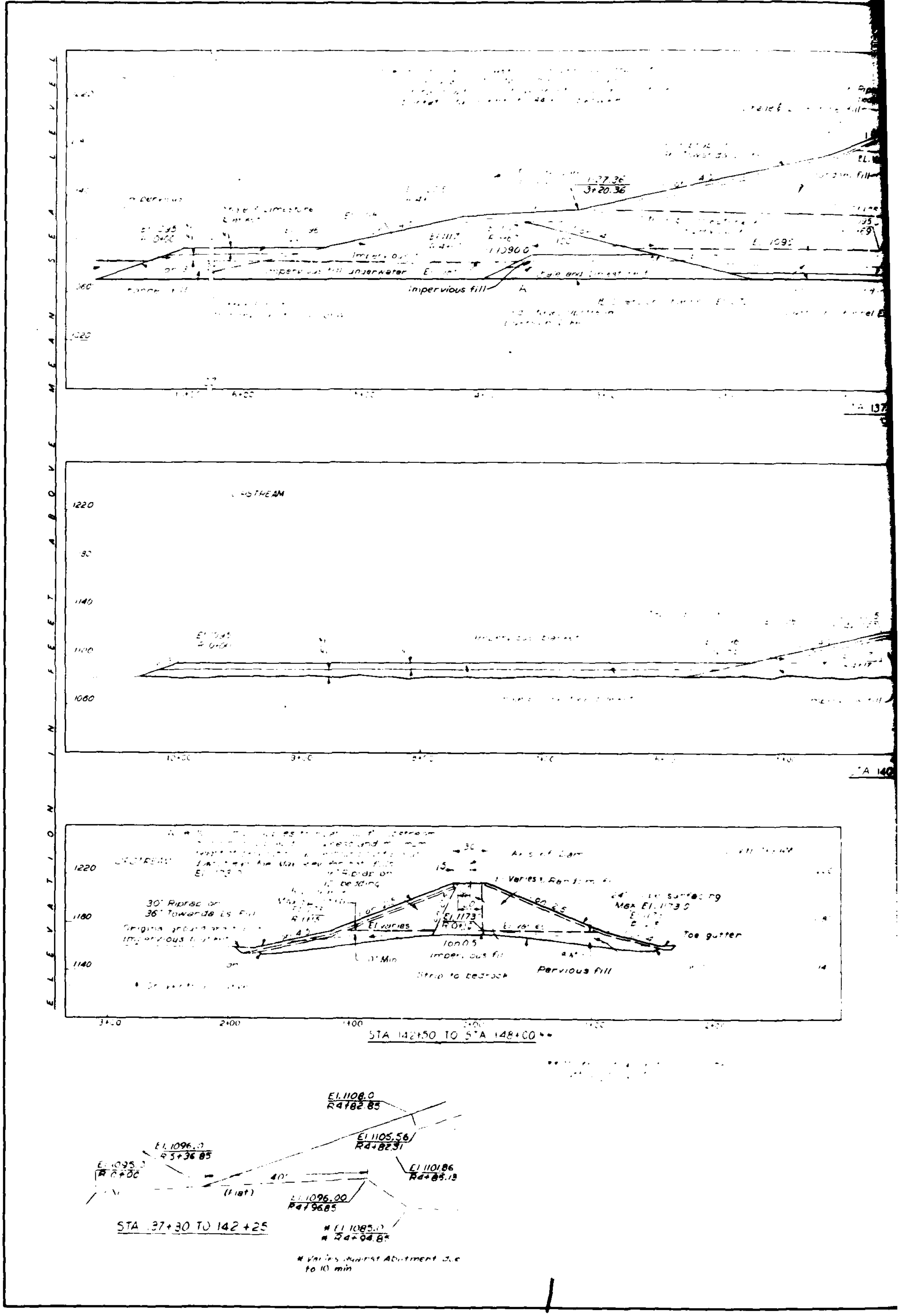
In 141 sheets — Sheet No. 10 — Scale: as shown

U. S. ARMY ENGINEER DISTRICT, KANSAS CITY — KANSAS CITY, MO., APRIL 1962

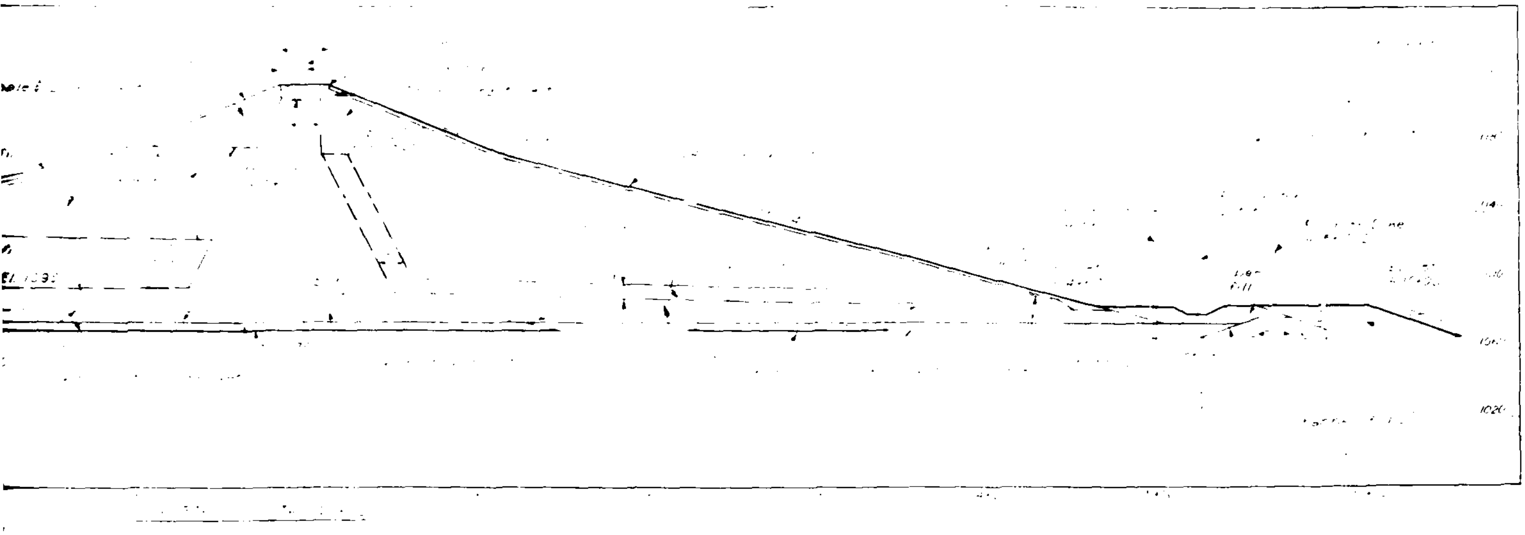
Submitted: CHIEF, DESIGN SECTION — Recommended: J. F. Redlinger, CHIEF, FOUNDATIONS & MATLS. BR. — Approved: CHIEF, ENGINEERING DIVISION

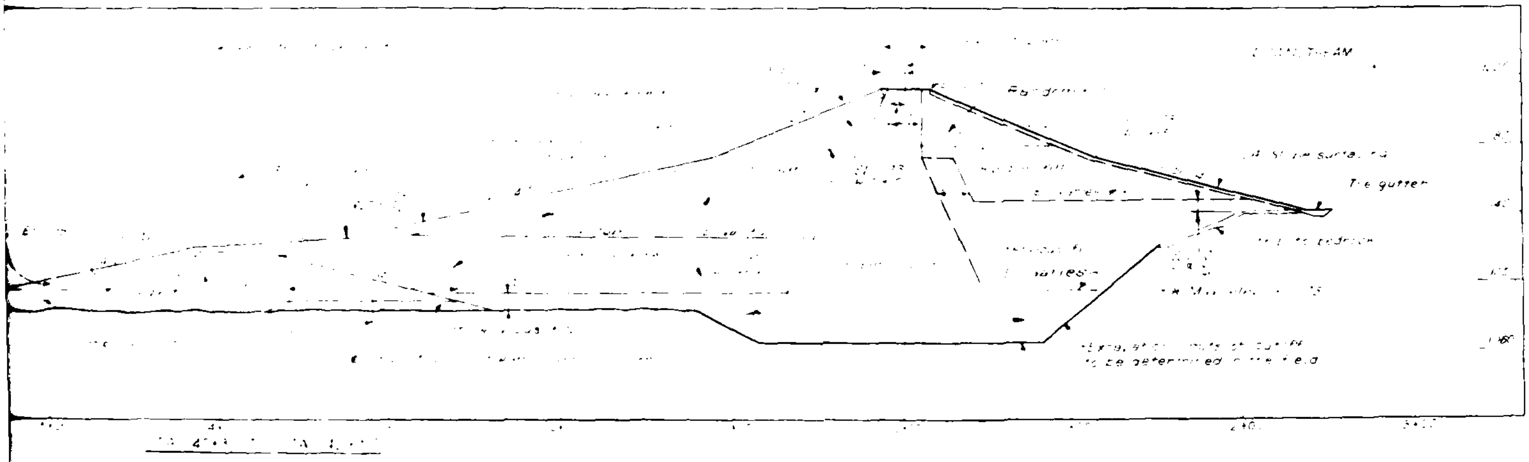
DRAWN BY C G F — TRACED BY J R P — CHECKED BY — FILE NO. B-1-910

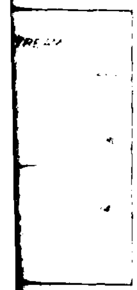
PLATE NO. 8

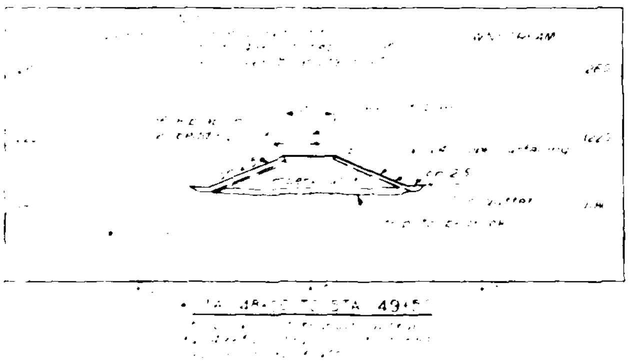

ELEVATION IN FEET ABOVE MEAN SEA LEVEL
Impervious fill
Impervious fill underwater
1127.36
3+20.36
El. 1095
1220
1180
1140
1100
1060
30" Riprap on
36" Towards Ls Fill
Toe gutter
Pervious fill
Strip to bedrock
Impervious fill
STA 142+50 TO STA 148+00 **
El. 1108.0
R4+82.85
El. 1096.0
R5+36.85
El. 1095.0
R6+00
El. 1105.56
R4+82.31
El. 1101.86
R4+85.13
40'
(Flat)
El. 1096.00
R4+96.85
* El. 1085.0
* R4+94.8*
* Varies against Abutment due to 10 min
STA 137+30 TO 142+25

U S ARMY









RECORD DRAWING

DECEMBER 1966

CONTRACT NO DA 23-028-CIVENG-62 739

SYM	DESCRIPTION	DATE	APP'D
Ⓐ	[illegible]	[illegible]	[illegible]

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

EMBANKMENT SECTIONS

In 41 sheets — Sheet No 11 — Scale as shown

U S ARMY ENGINEER DISTRICT KANSAS CITY

KANSAS CITY, MO APRIL 1962

Submitted: CHIEF [illegible] SECTION

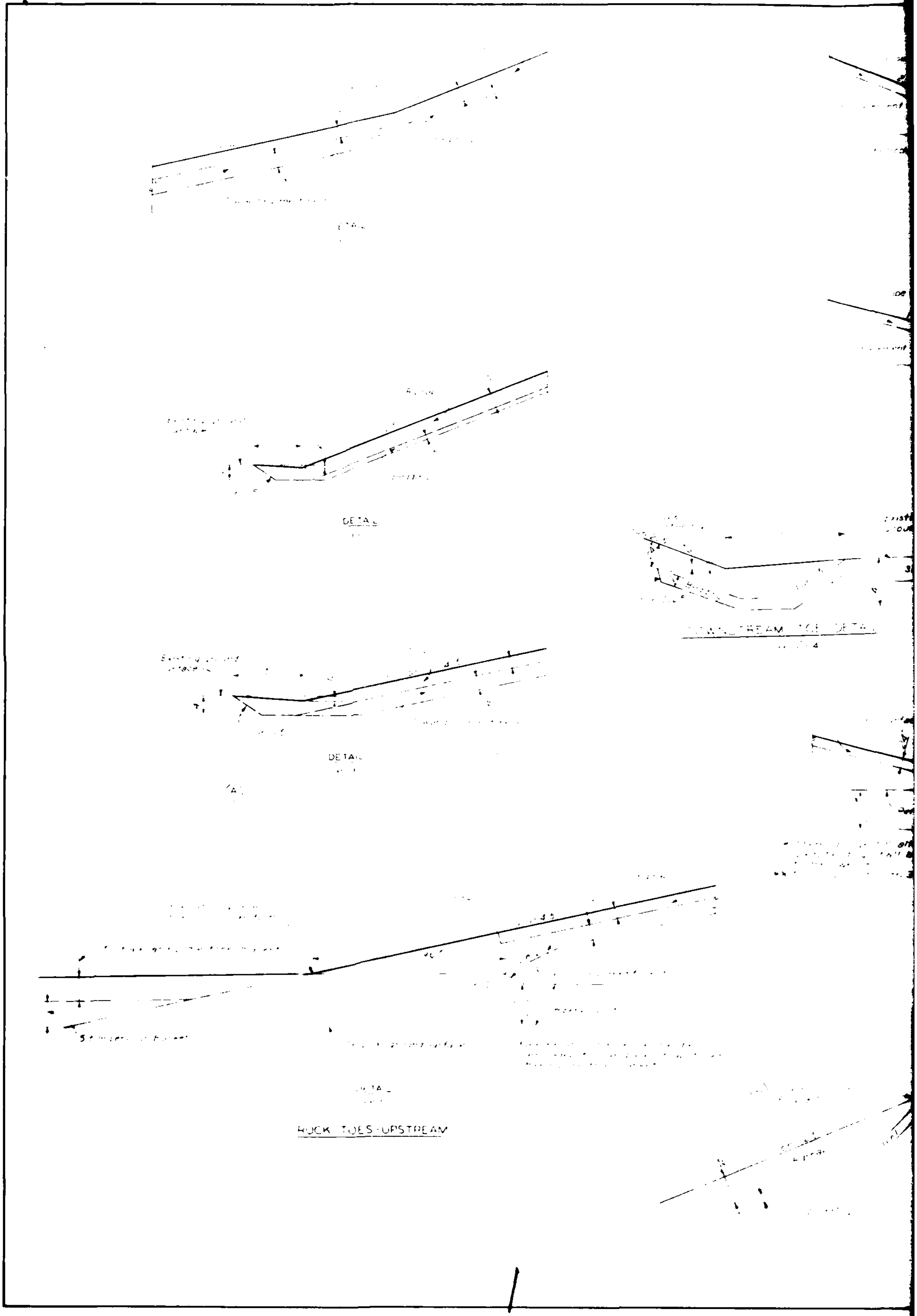
Recommended: CHIEF FOUNDATIONS & MATLS BR

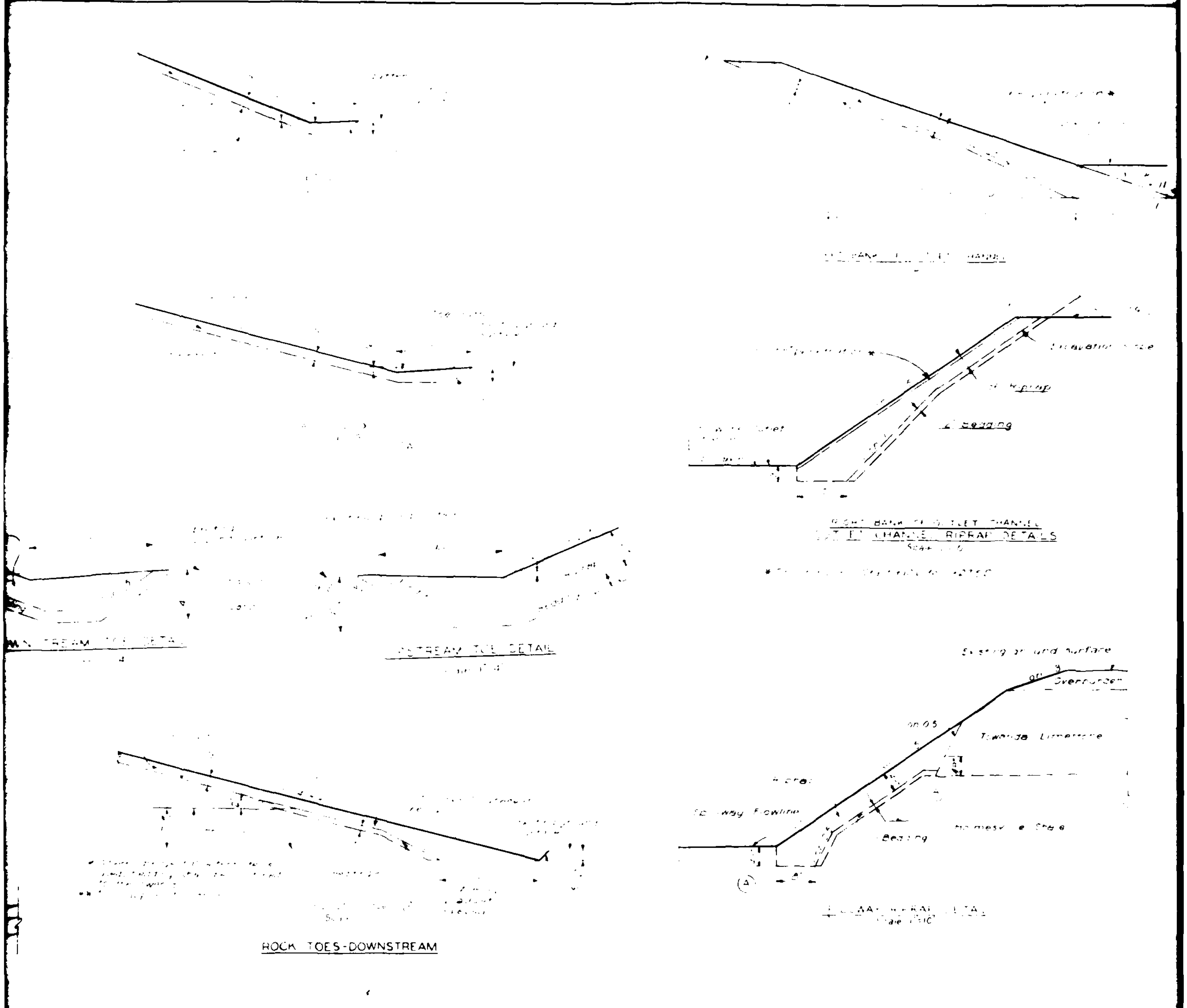
Approved: CHIEF ENGINEERING DIVISION

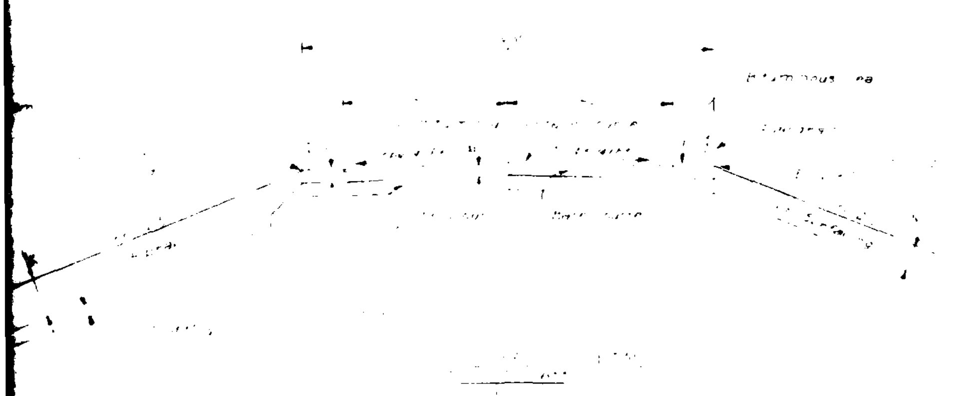
DRAWN BY CGF — TRACED BY JRP — CHECKED BY [illegible]

FILE NO [illegible]

CORPS OF ENGINEERS







RECORD DRAWING

DECEMBER 1966

CONTRACT NO DA-23-028-CIVENG-62 739

SYM	DESCRIPTION	DATE	APP'D
	Revised for As Built conditions	5-6-69	
Ⓐ	Changed as per Amendment No. 16	7-24-62	
	REVISIONS		

REPUBLICAN RIVER, KANSAS

MILFORD DAM

RIPRAP AND SLOPE PROTECTION DETAILS

In 141 sheets Sheet No. 12 Scale: as shown

U. S. ARMY ENGINEER DISTRICT KANSAS CITY KANSAS CITY, MO. APRIL 196

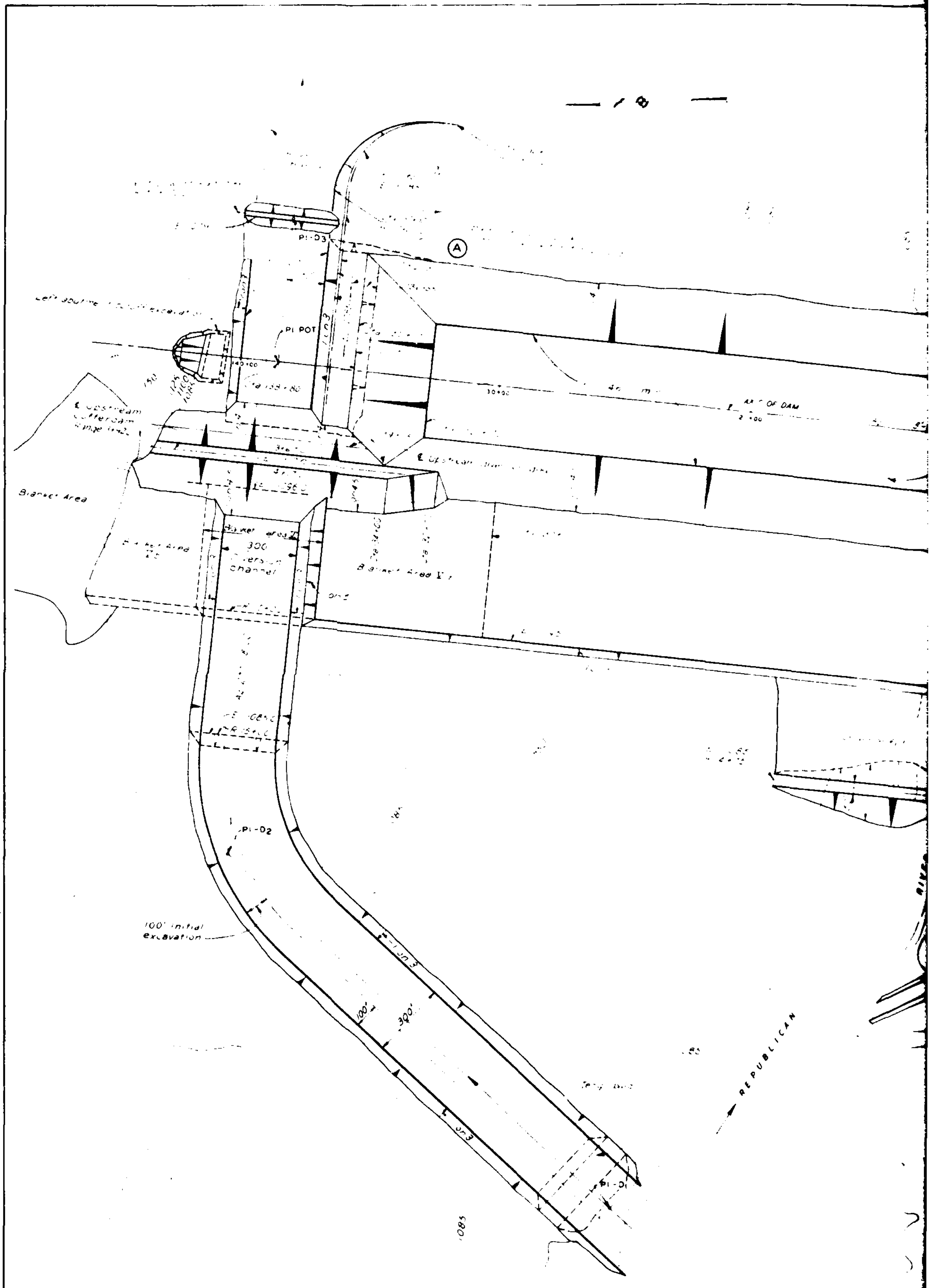
Submitted: CHIEF, ... SECTION Recommended: J. T. Redlinger CHIEF FOUNDATIONS & MATLS. BR. Approved: CHIEF ENGINEERING DIVISION

DRAWN BY C.G.F. TRACED BY J.R.P. CHECKED BY R.L.B.

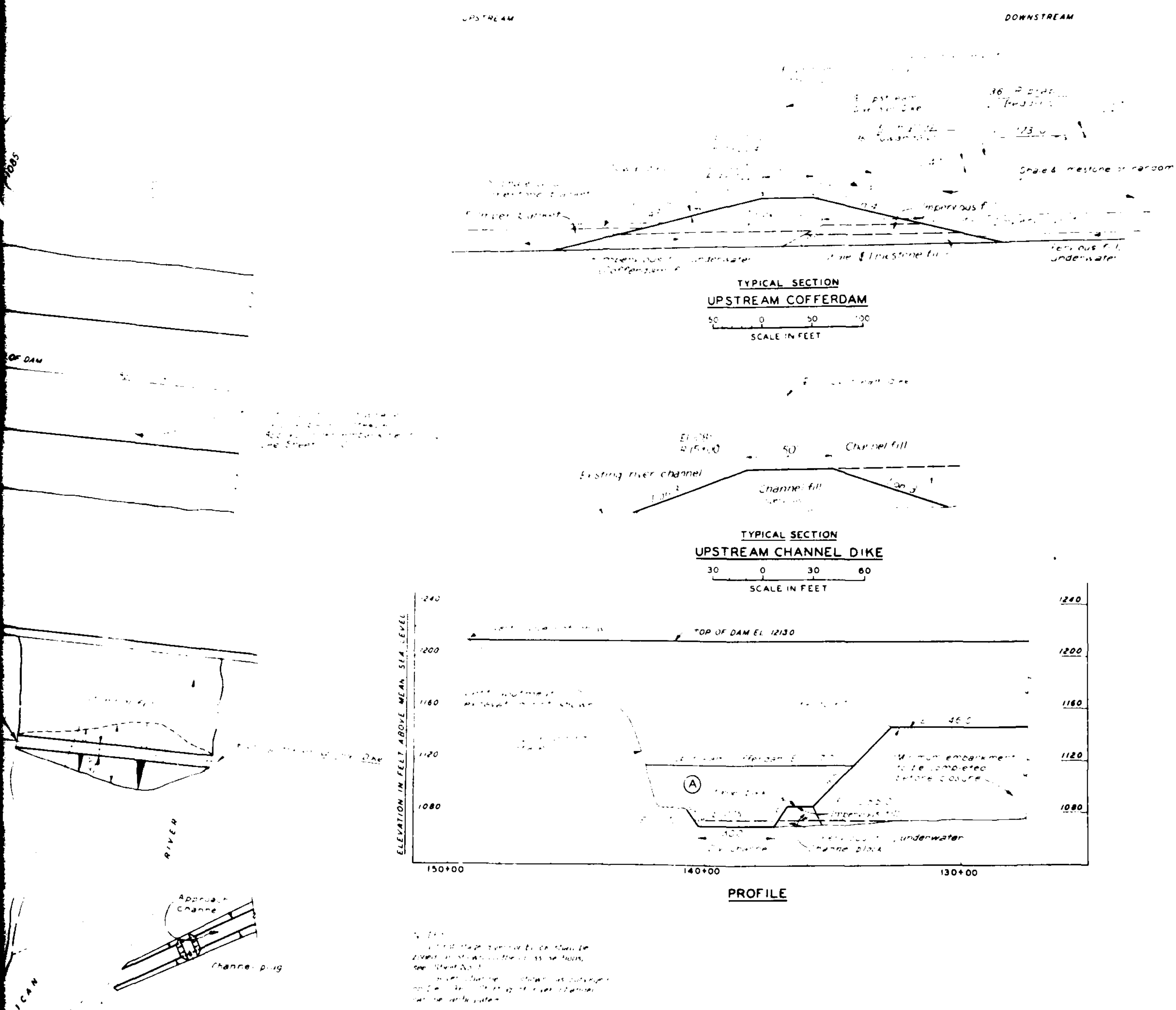
FILE NO. B-1-86

PLATE NO.

CORPS OF ENGINEERS



US ARMY



RECORD DRAWING

DECEMBER 1966

CONTRACT NO DA 23 028-CIVENG-62 739

SYM	DESCRIPTION	DATE	APP'D
	Revised for As Built conditions	5-6-69	
Ⓐ	Changed as per Amendment No. 1	7-24-62	
	REVISIONS		

REPUBLICAN RIVER, KANSAS

MILFORD DAM

DIVERSION AND CLOSURE

In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

Sheet No. 13

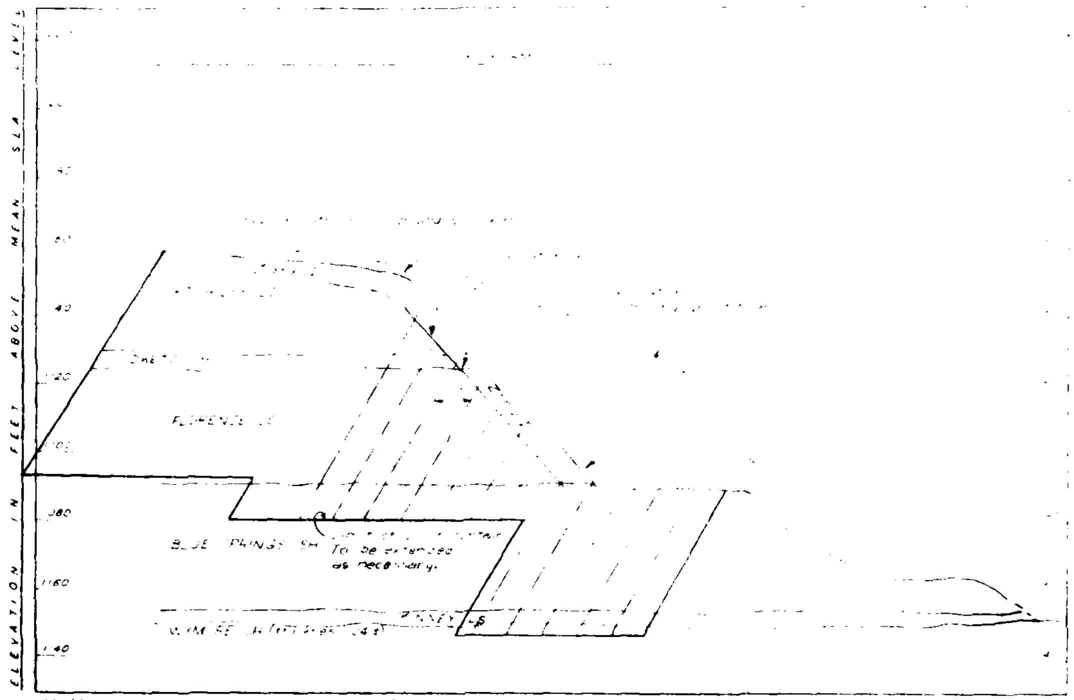
Scale: as shown
KANSAS CITY, MO.
APRIL 1962

Submitted: CHIEF, DESIGN SECTION
Recommended: CHIEF, FOUNDATIONS & MATLS BR
Approved: CHIEF, ENGINEERING DIVISION

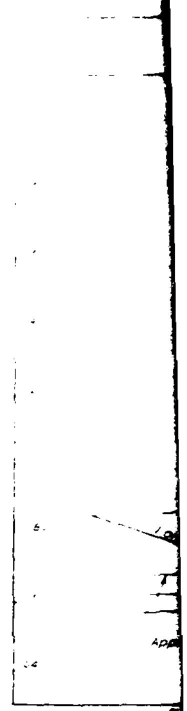
DRAWN BY C.G.F. TRACED BY P.F.M. CHECKED BY R.L.B.

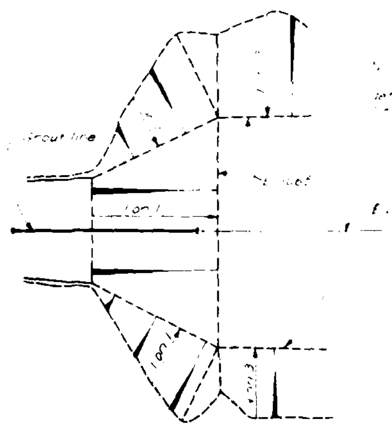
FILE NO. 8-1-813

PLATE NO. 11



PROFILE
LEFT ABUTMENT GROUT CURTAIN





PLAN
LEFT ABUTMENT GROUT CURTAIN
No Scale

VOTES

Grouting done by stage method

Primary holes drilled on 10ft spacing and locations of all intermediate holes determined by the split spacing method

Grout holes drilled at an angle of 30° from vertical into their respective abutments unless otherwise directed

Grouting under the conduit done after preliminary excavation.

Grout hole spacing measured on a horizontal plane and numbered by dam axis stationing at collar of hole

Drilling and grouting acomplished in two zones with stages as specified, but modified in the field.

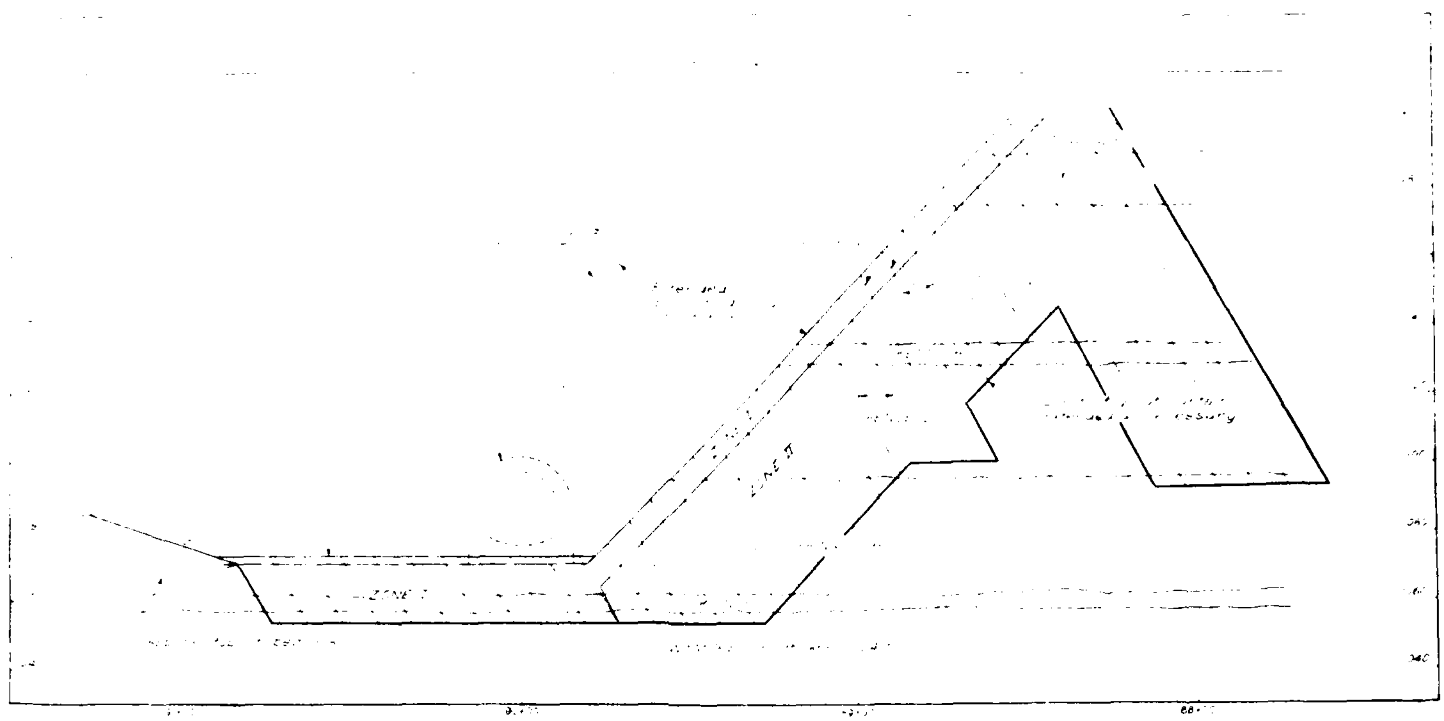
For excavation details of abutments and conduit, see Sheet No 19

For description of geologic formations, see Sheet No 125

* Grout curtain extended as necessary to tie with existing grout curtain constructed by others.

Only primary grout holes are shown on profiles.

U. S. ARMY



[illegible]
[illegible] AND RIGHT ABUTMENT
GROUT CURTAIN

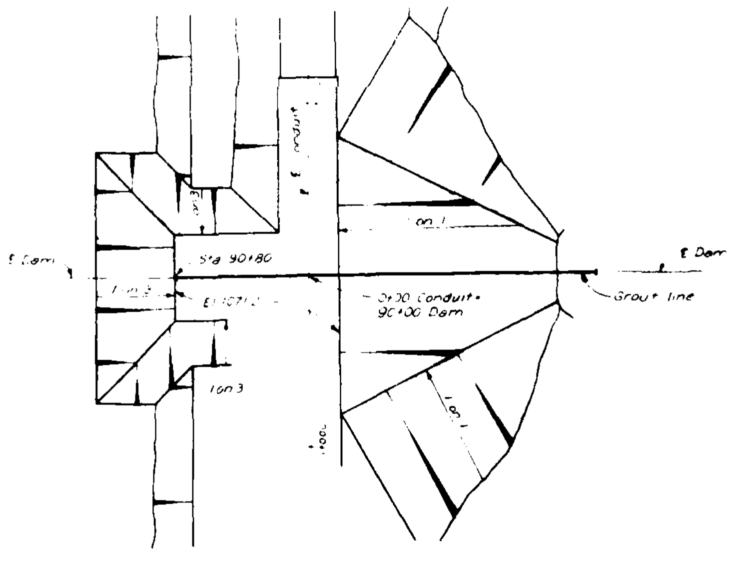
NOTE
[illegible] curtain [illegible]
[illegible]

Left Abutment
Sta 42 [illegible] Dam

Right Abutment
The right abutment grout curtain is located [illegible] approximately [illegible] Dam and extends [illegible] the following points:

[illegible]	[illegible]
84+60.00	
85+62.03	[illegible] 00 Upstream
87+02.34	[illegible] 85 Upstream
80+01.42	
85+64.42	

These [illegible] were in general brought to the bottom of the Florence limestone. The stop [illegible] method was employed.



PLAN
CONDUIT AND RIGHT ABUTMENT
GROUT CURTAIN

40 0 40 80
SCALE IN FEET

REPUBLICAN RIVER, KANSAS
MILFORD DAM
CURTAIN GROUTING
PLANS AND PROFILES

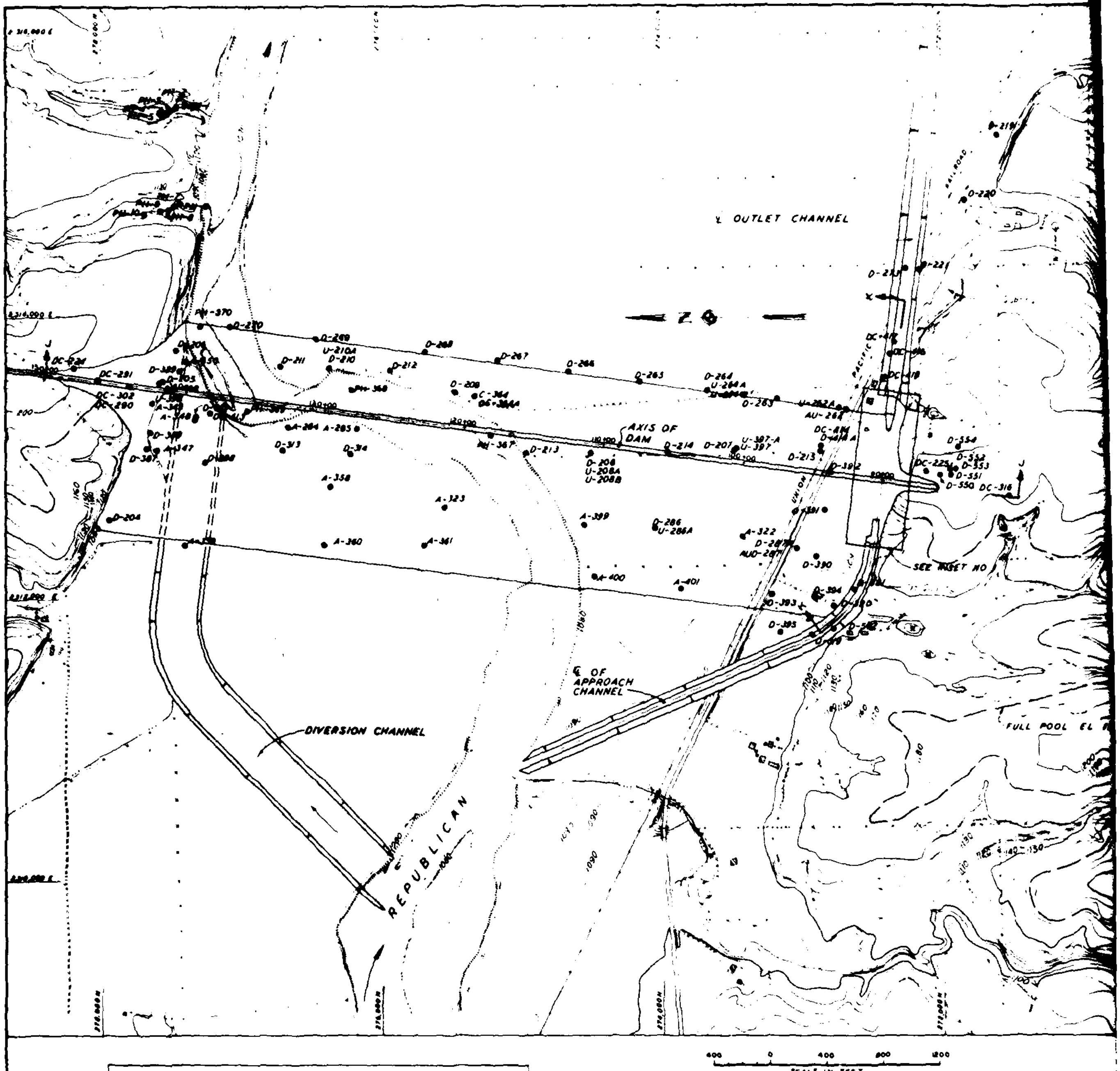
RECORD DRAWING
DECEMBER 1966
CONTRACT NO. DA-23-028-CIVENG-62 739

SYM.	DESCRIPTION	DATE	APP'D.
Ⓐ	Revised for As Built conditions		
	Changed as per Amendment No 1	7-24-62	
	REVISIONS		

In 141 sheets
Sheet No. 14
Scale: as shown
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY
KANSAS CITY, [illegible]
APRIL [illegible]

Submitted: CHIEF, GEOLOGY SECTION
Recommended: J. F. Redlinger, CHIEF, FOUNDATIONS & MATLS BR.
Approved: CHIEF, ENGINEERING DIVISION
DRAWN BY J K S. TRACED BY J R P CHECKED BY C R G
PLATE NO.

CORPS OF ENGINEERS



NO &

HOLE NC

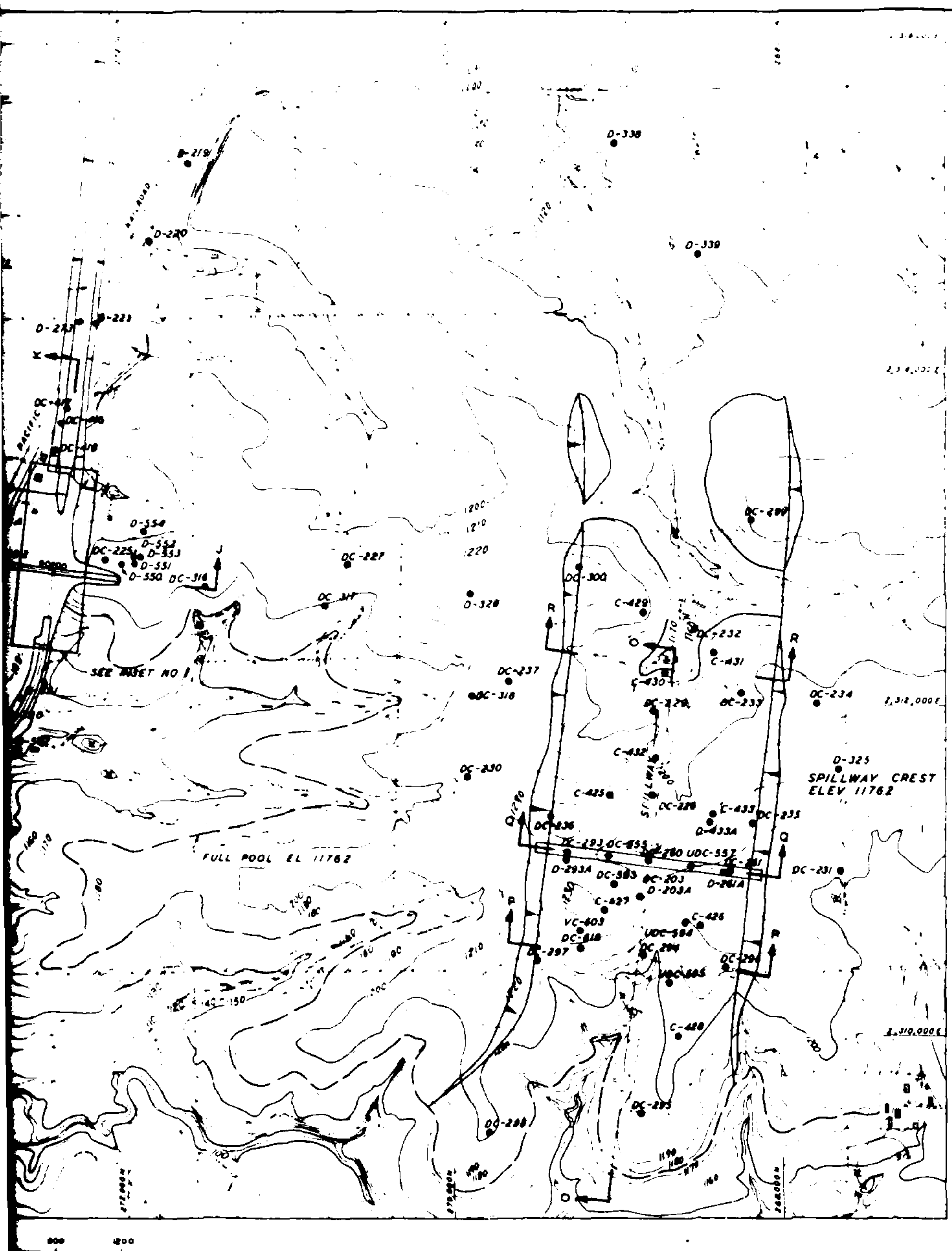
C 15

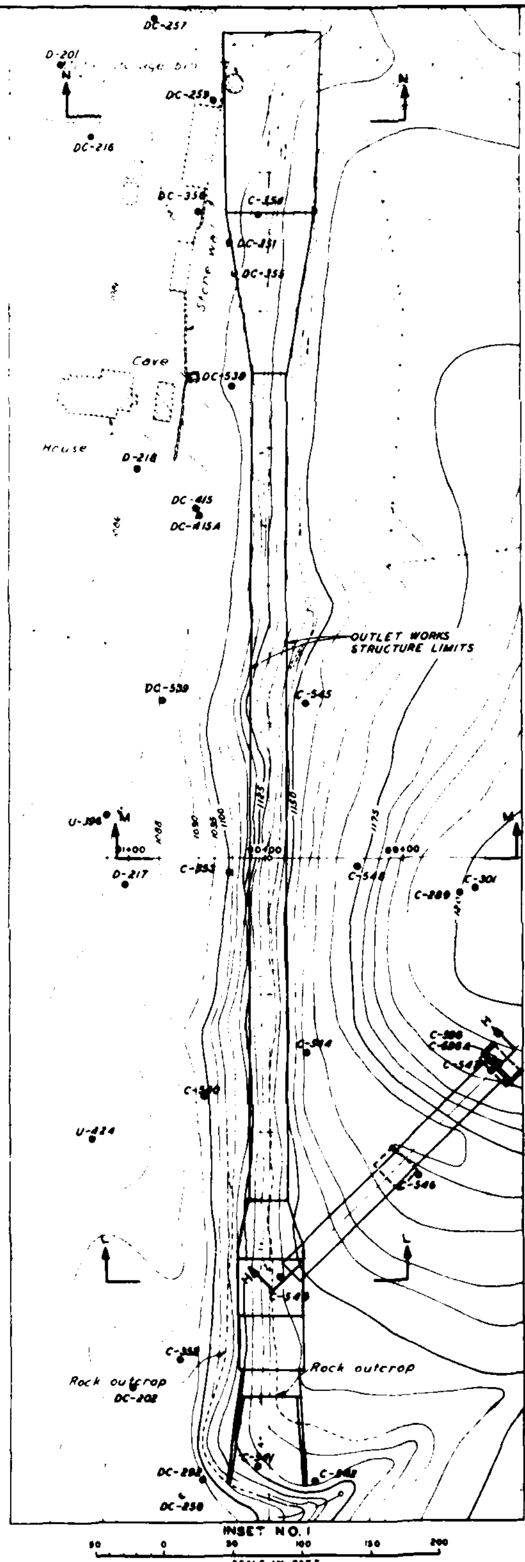
LOCATION - REFERENCE TO DAM AXIS

*BORING NO.	STATION	RANGE
U-434	90+86	4+85D
U-435	91+74	5+02D
U-436	105+95	4+85D
U-437	100+00	4+80D
U-438	106+30	4+80D
U-439	110+20	4+70D
U-440	116+15	4+90D
U-441	119+90	4+85D
U-442	120+02	4+90D
U-443	125+02	5+00D
U-444	128+10	4+95D
U-445	133+00	4+90D
U-446	130+30	4+90D
U-447	112+50	4+90D
U-448	134+80	5+00D
U-449	129+20	5+00D
U-450	123+85	5+03D
U-451	117+25	5+00D
U-452	114+25	4+85D
U-453	111+40	4+65D
U-454	109+20	4+70D
U-455	94+70	4+80D
PH-617	113+00	4+20U
PH-618	115+00	4+20U
PH-619	117+00	4+20U
PH-620	120+80	1+60U
PH-621	120+80	0+20U
PH-622	120+80	1+30D
PH-623	135+40	2+40D
PH-624	137+20	2+40D
PH-625	139+00	2+40D

* These borings are not shown. Logs are available for inspection at the Kansas City District Office

B





NO & TYPE OF EXPLORATION

HOLE NO. CODE DESIGNATION

Ⓑ NOTES:

For plan of explorations in borrow areas, see Sheet No 124.

For profiles, cross sections, and logs of borings see Sheet Nos 129 thru 133.

Soundings made in the Republican River channel on 9 May 1962, by Probe Holes 617-625, indicate that the riverbed consisted of generally fine to medium sands to a depth of one to two feet, which was the total depth of the sounding.

RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA 23 028 CIVENG 62 739

REPUBLICAN RIVER, KANSAS

MILFORD DAM

PLAN OF EXPLORATIONS EMBANKMENT AND STRUCTURE AREAS

SYM	DESCRIPTION	DATE	APP'D
	Revised for As Built conditions		
Ⓑ	Changed as per Amendments Nos 1&2	24-62	
Ⓐ	Added borings DC 555, UDC-557, DC 593, UDC-594, UDC-595, C 596, C 596A, C 616, and UC-603	5-10-62	
	REVISIONS		

In 141 sheets. Sheet No. 123. Scale: as shown

U. S. ARMY ENGINEER DISTRICT, KANSAS CITY. KANSAS CITY, MO. APRIL 1962

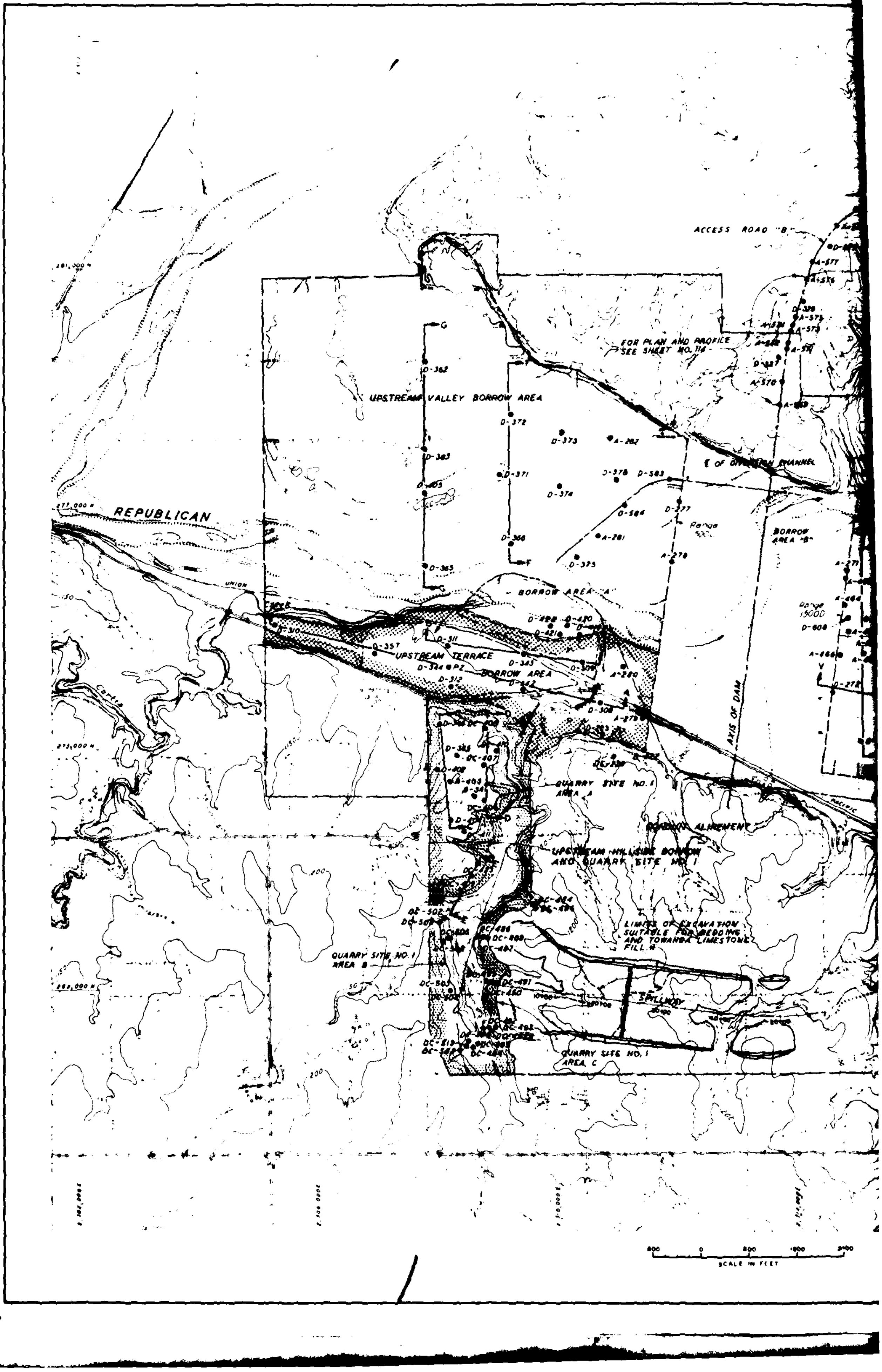
Submitted: CHIEF, GEOLOGY SECTION. Recommended: Q. J. Redlinger, CHIEF, FOUNDATIONS & ... SEC. Approved: CHIEF, ENGINEERING DIVISION

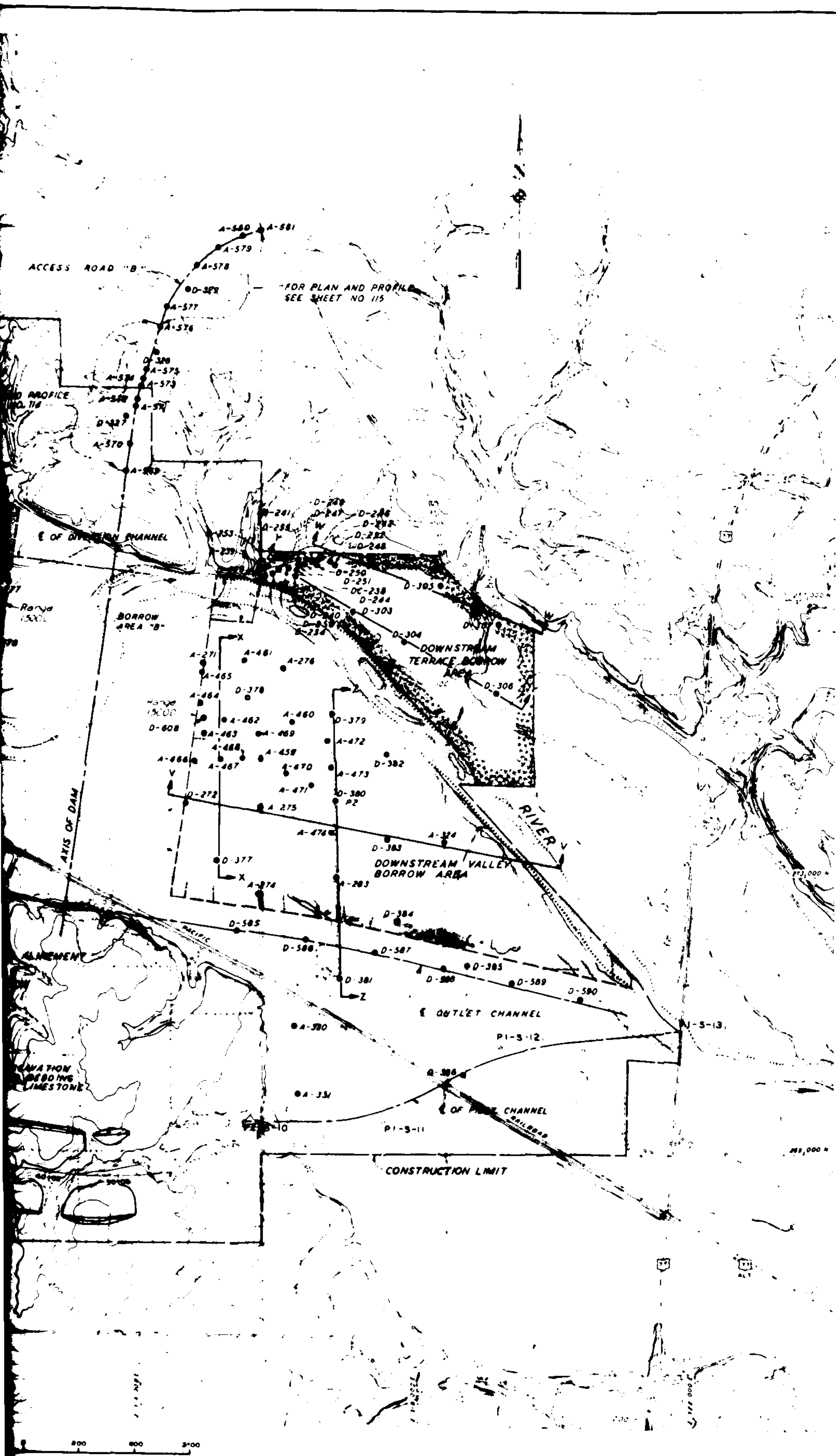
DRAWN BY J.K.S. TRACED BY C.L.W. CHECKED BY C.R.G.

FILE NO. 9-1-...

PLATE NO. 13

CORPS OF ENGINEERS





NO & TYPE OF EXPLORATION

BORINGS

PH Probe hole

NOTES

For plan of borings in vicinity of axis of dam and spillway, see Sheet No 123

For cross sections in borrow areas see Sheet No's 126, 127 & 128

For profile of access road "B" see Sheets Nos 114 & 115

For plan of borings in Quarry Site No 1, see Sheet No. 134

* Bedding and Towanda Limestone fill production is restricted to the lower Towanda Limestone with in the limits as shown

For the geology of the spillway area, see Sheet No 130

For plan of explorations in embankment and structure areas, see Sheet No 123

For profiles and logs of borings, see Sheet No's. 114, 115, 126, 127, 128 & 134

Fine aggregate may be produced from the section of Borrow Area "A" adjacent to the river however the operation must be so regulated as to comply with section 4, paragraph 13b (6) in the specifications

RECORD DRAWING

DECEMBER 1966

CONTRACT NO DA-23-028-CIVENG-62-739

SYM	DESCRIPTION	DATE	AP
	Revised for "As Built" conditions	5-6-69	
A	Added borings A-460 thru A-474, D-606 Added Borrow Area "B" limits Extended limits Borrow Area "A"	5-10-62	

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

PLAN OF EXPLORATIONS BORROW AND QUARRY AREAS

In 141 sheets | Sheet No. 124 | Scale: as sh

U S ARMY ENGINEER DISTRICT KANSAS CITY

KANSAS CITY, APRIL

Submitted: CHIEF, GEOLOGY SECTION

Recommended: J. F. Redlinger, CHIEF, FOUNDATIONS & MATLS BR

Approved: CHIEF, ENGINEERING

DRAWN BY JKS | TRACED BY J.R.P | CHECKED BY CRC

B-1-

PLATE NO.

1

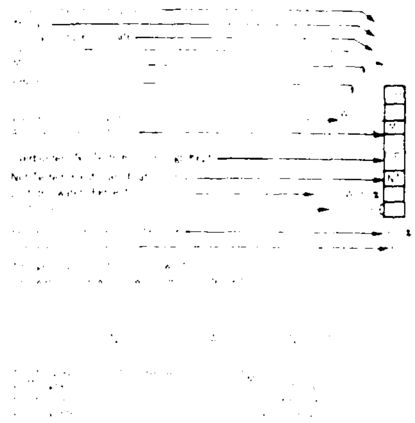
2

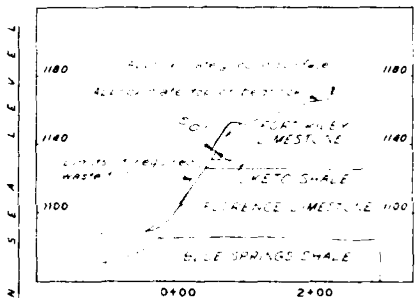
CORPS OF ENGINEERS

GENERAL GEOLOGIC COLUMN

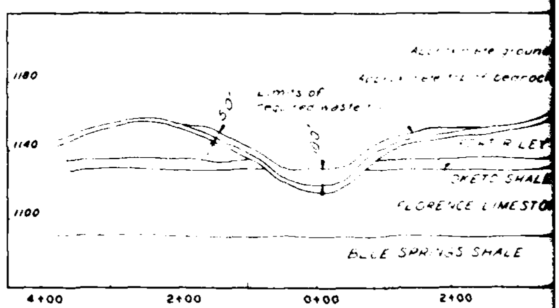
SYSTEM	FORMATION	MEMBER	UNIT	AVERAGE THICKNESS	SYMBOL	GENERAL DESCRIPTION
QUATERNARY	WISCONSINIAN TERRACE & RECENT ALLUVIUM			44.0'		[illegible] terraces [illegible]
	LOVELAND & PEORIA (UNDIFFERENTIATED)			20'		[illegible] the uplands adjacent to the Republican River valley
PERMIAN	DOYLE SHALE	GAGE SHALE	Ga	0-2'+		Shale Massive#, soft greenish-grey
		TOWANDA LIMESTONE	To	3.5'		Limestone Thin-bedded, hard, dense, solution pitted, [illegible] bluish-grey
		HOLMESVILLE SHALE	Ho	5.5		Shale Laminated, soft, with discontinuous limestone beds toward the base, green and red
	BARNESTON LIMESTONE	FORT RILEY LIMESTONE	FR_a	20		Limestone Thin-bedded, contains thin shale beds near the top, moderately hard, argillaceous, dense, vuggy, greyish-brown
			FR_b	[illegible]		Limestone Medium-bedded, moderately hard, argillaceous, slightly vuggy, light gray
			FR_c	9.0		Limestone Thin-bedded, moderately hard, dense, argillaceous, light and dark grey
			FR_d	9.0		Limestone Massive##, hard, dense, solution-pitted, tan, "rim rock"
			FR_e	2.5'		Limestone Massive##, hard, fine grain
		OKETO SHALE	Ok	5.5'		Shale Massive#, calcareous, moderately hard, dark gray
		FLORENCE LIMESTONE	Fl_a	15.0'		Limestone Thin to medium bedded, hard, dense, cherty, contains occasional shaly zone, grey and tan
			Fl_b	10.0'		Limestone Massive##, hard, dense, vuggy, tan
			Fl_c	10.5'		Limestone Thin-bedded, hard, dense, cherty, tan and grey
			Fl_d	4.0'		Limestone Thin to medium bedded, dense, shaly at base, grey
	MATFIELD SHALE	BLUE SPRINGS SHALE	BS_a	20.0'		Shale Massive#, soft, calcareous with limestone bed near base, red and green
			BS_b	11.0'		Shale fissile, moderately hard, calcareous, slightly mineralized with gypsum, dark grey.
		KINNEY LS	Ki	5.5'		Limestone Thin-bedded, hard, dense, argillaceous, grey
		WYMORE SHALE	Wy_a	10.0'		Shale Laminated, moderately hard, calcareous, dark grey
			Wy_b	14.0'		Shale Massive#, soft, calcareous, scattered limestone nodules and slight gypsum mineralization, greenish-grey and red
	WREFORD LIMESTONE	SCHROYER LS	Sc	10.5'		Limestone Medium to thick bedded, hard, dense, shaly and cherty
		HAVENSVILLE SHALE	Ha	13.5'±		Shale Massive to laminated, soft to moderately hard, generally dark gray to black, contains argillaceous limestone beds

"Massive" - (as used in reference to shales) Of homogeneous structure without stratification, as defined in (a) page 179 of the "Glossary of Geology and Related Sciences," published by the American Geological Institute
"Massive" - (as used in reference to limestone) Made up of beds over 2 feet thick

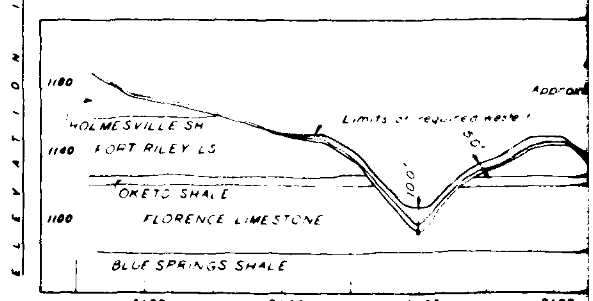




WASTE AREA NO. 2 SECTION AA-AA

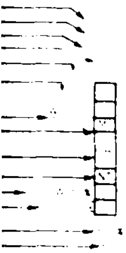


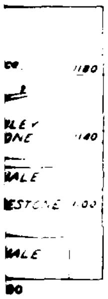
WASTE AREA NO. 2 SECTION CC-CC

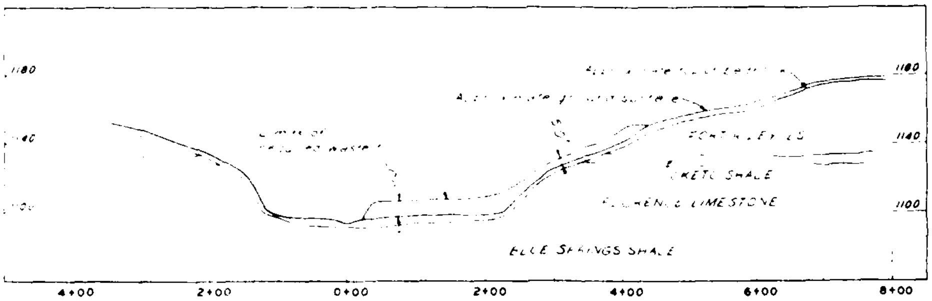


WASTE AREA NO I SECTION

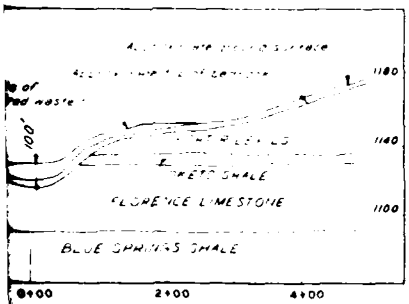
US ARMY



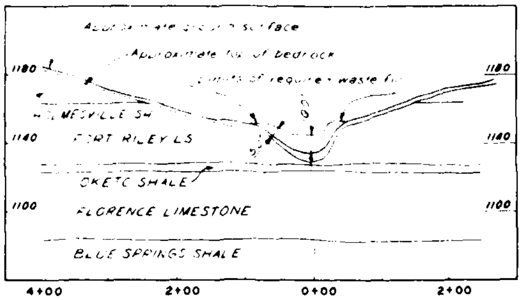




WASTE AREA NO 2 SECTION BB-BB

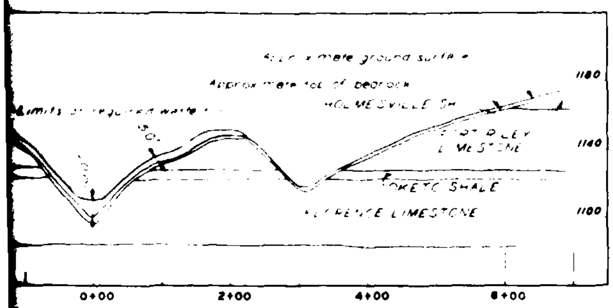


NO. 2 SECTION CC-CC



WASTE AREA NO. I SECTION DD-DD

NOTE: For location of waste area profiles, see Sheet No 4



WASTE AREA NO I SECTION EE-EE

RECORD DRAWING

DECEMBER 1966

CONTRACT NO DA 23-028-CIVENG-62-739

SYM.	DESCRIPTION	DATE	APP'D
	Revised for As Built conditions		
A	Changed as per Amendment No		

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

GEOLOGIC COLUMN AND LEGEND FOR EXPLORATIONS, PROFILES WASTE AREAS NOS. 1 AND 2.

In 141 sheets — Sheet No 125 — Scale: as shown

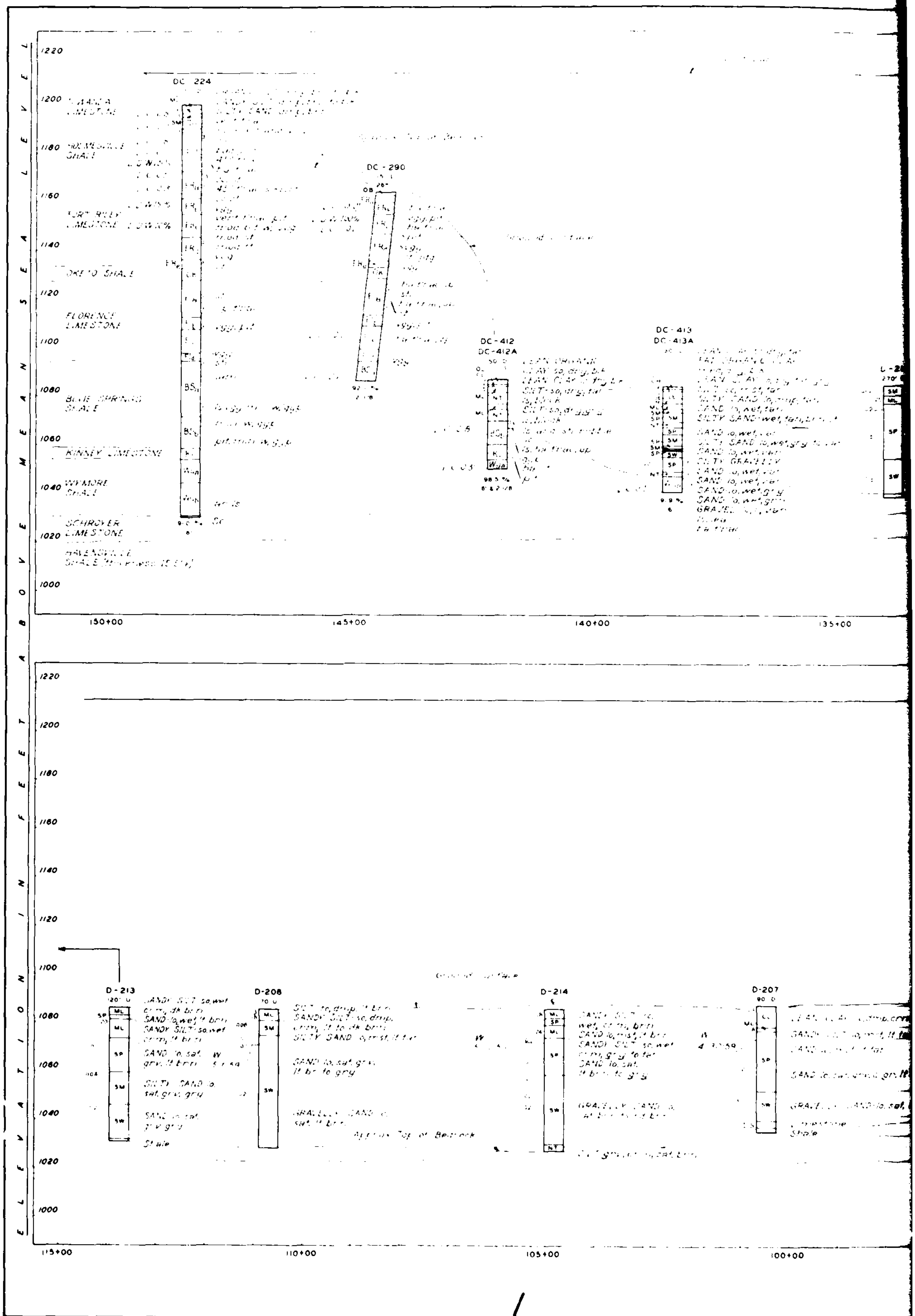
U. S. ARMY ENGINEER DISTRICT KANSAS CITY — KANSAS CITY, MO APRIL 1962

Submitted: Chief, Geology Section — Recommended: Chief, Foundations & Materials Br. — Approved: Chief, Engineering Division

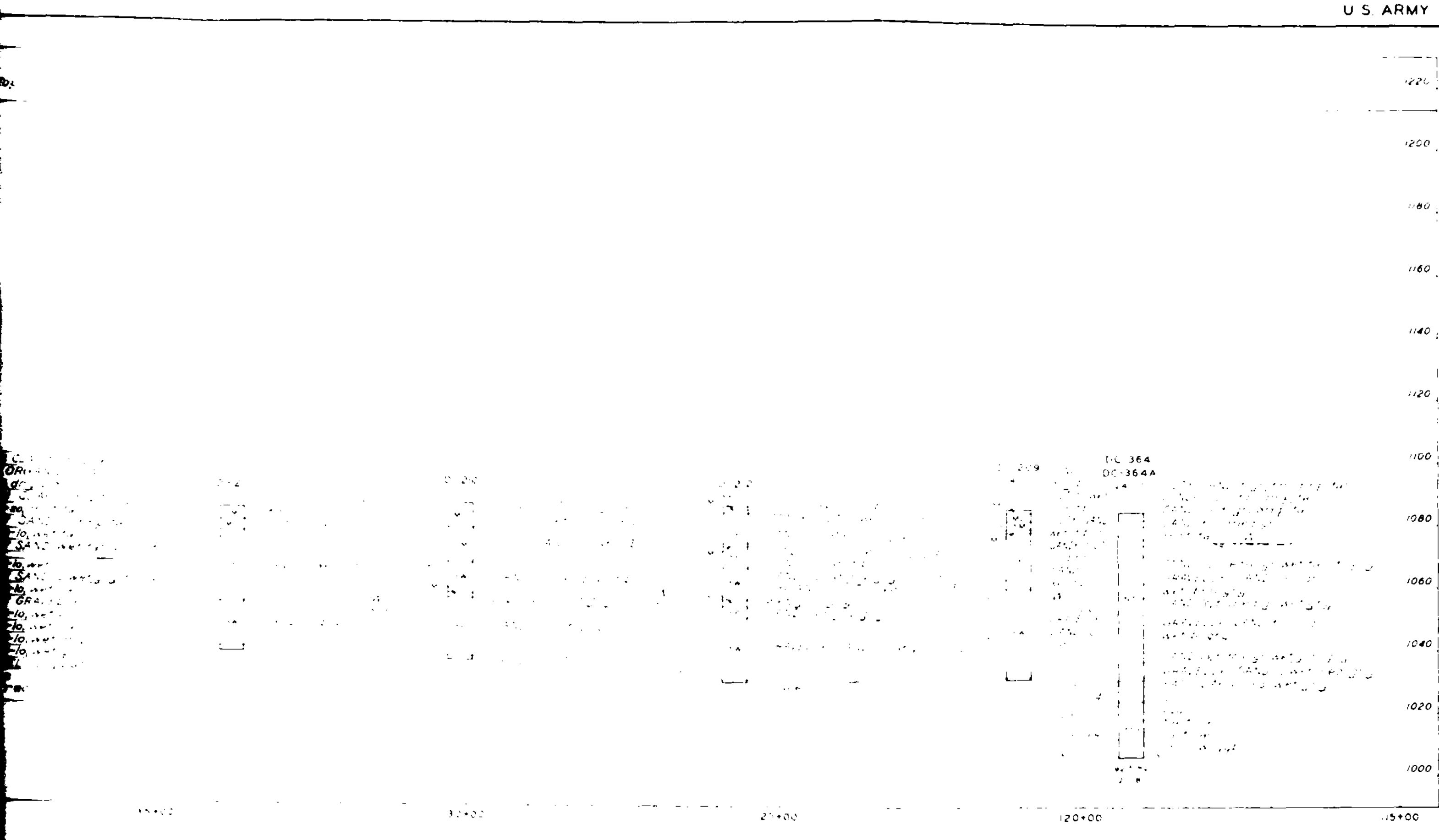
Drawn by J.K.S. — Traced by R.F.M. — Checked by C.R.G. — File No B-1-1028

PLATE NO. 15

CORPS OF ENGINEERS



U.S. ARMY



RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA 23 028 CIVENG 62 739

SYM	DESCRIPTION	DATE	APP'D
A			

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

LOGS OF EXPLORATIONS DAM AXIS PROFILE J-J

In 141 sheets — Sheet No 129 — Scale as shown

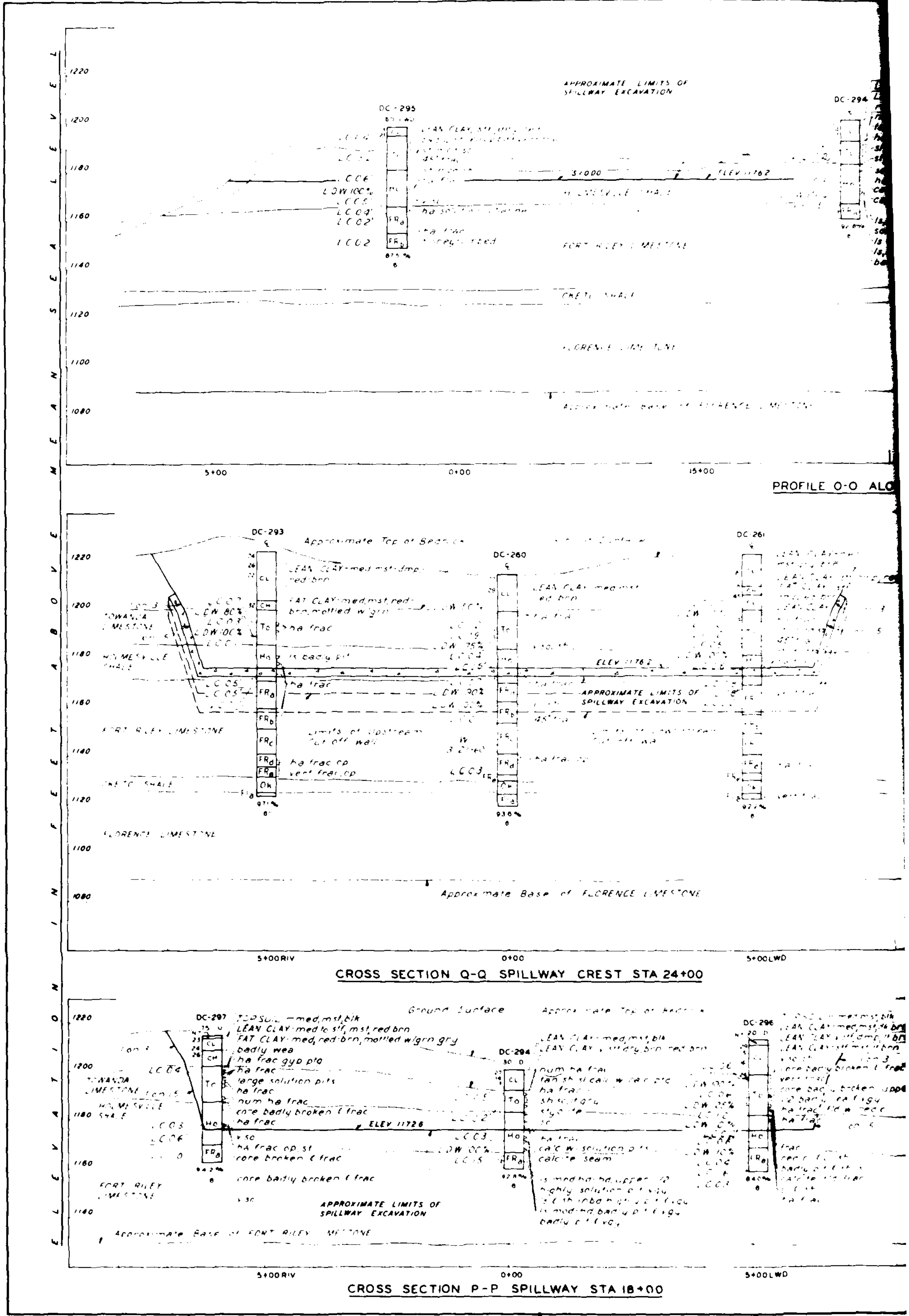
U. S. ARMY ENGINEER DISTRICT, KANSAS CITY — KANSAS CITY, MO — APRIL 1962

Submitted: CHIEF, GEOLOGY SECTION — Recommended: CHIEF, FOUNDATIONS & MATLS BR — Approved: CHIEF, ENGINEERING DIVISION

DRAWN BY K.S. — TRACED BY J.A.W. — CHECKED BY

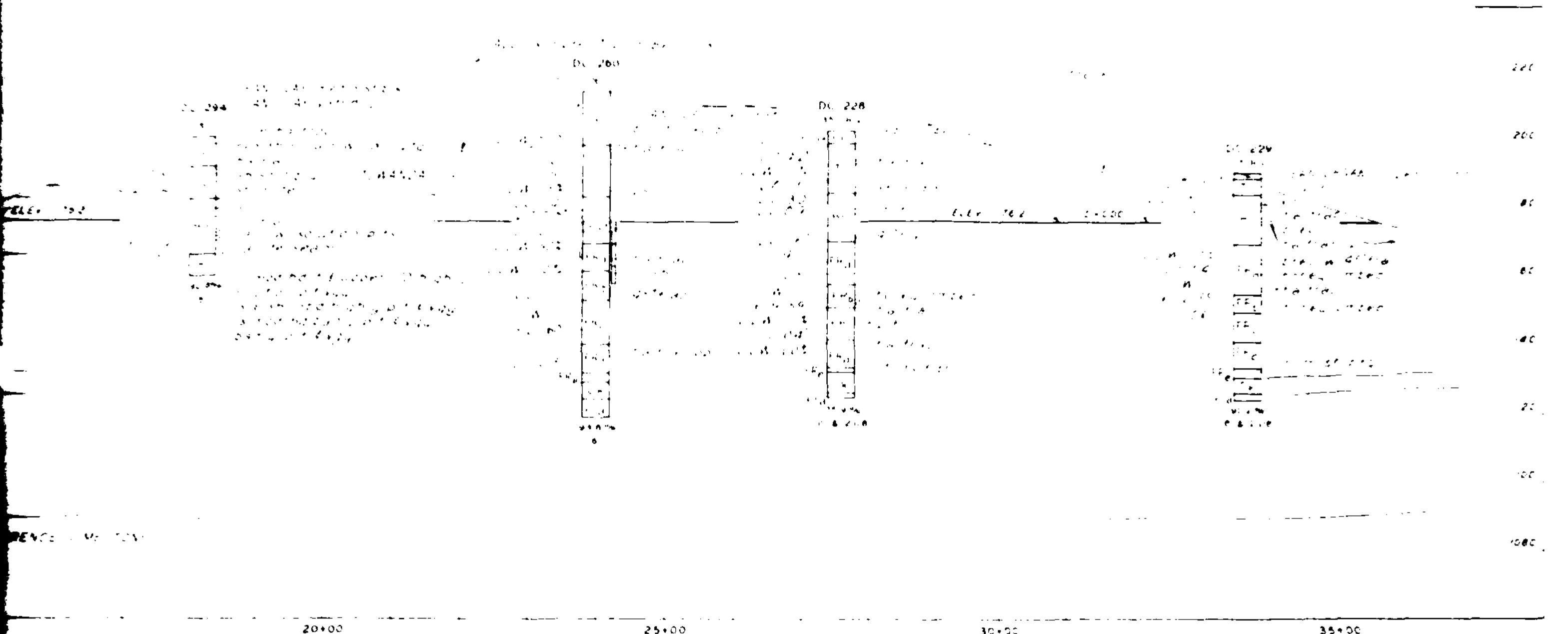
FILE NO. B-1-1029

PLATE NO. 16

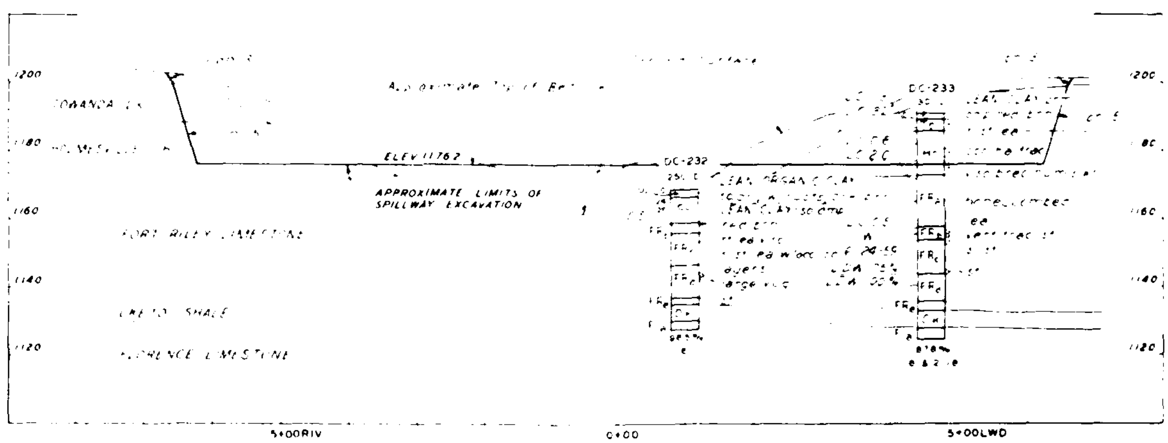


CROSS SECTION Q-Q SPILLWAY CREST STA 24+00

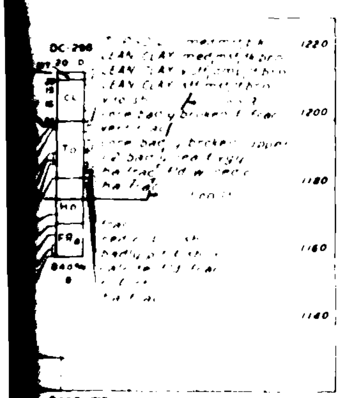
CROSS SECTION P-P SPILLWAY STA 18+00



PROFILE O-O ALONG CENTERLINE OF SPILLWAY



CROSS SECTION R-R SPILLWAY STA 36+00



RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA 23-028-CIVENG-62-739

SYM	DESCRIPTION	DATE	APP'D
A	Changes as per Amendment No.		

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

LOGS OF EXPLORATIONS SPILLWAY

In 141 sheets Sheet No. 130 Scale as shown

U. S. ARMY ENGINEER DISTRICT KANSAS CITY

KANSAS CITY, MO. APRIL 1962

Submitted: CHIEF, GEOLOGY SECTION

Recommended: CHIEF, FOUNDATIONS & MATLS. BR.

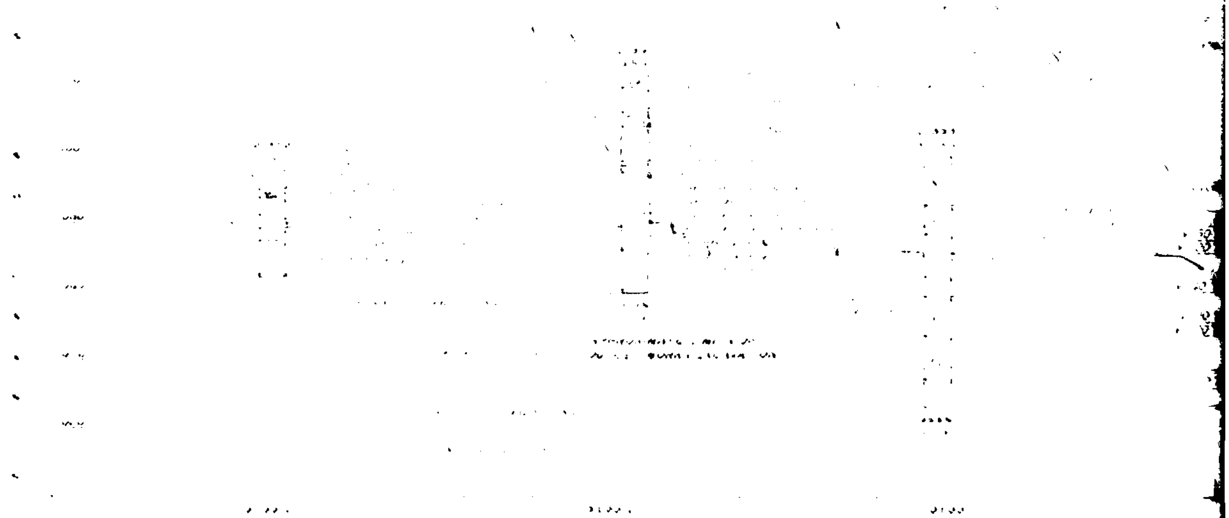
Approved: CHIEF, ENGINEERING DIVISION

DRAWN BY J.K.S. TRACED BY C.E.W. CHECKED BY C.R.G.

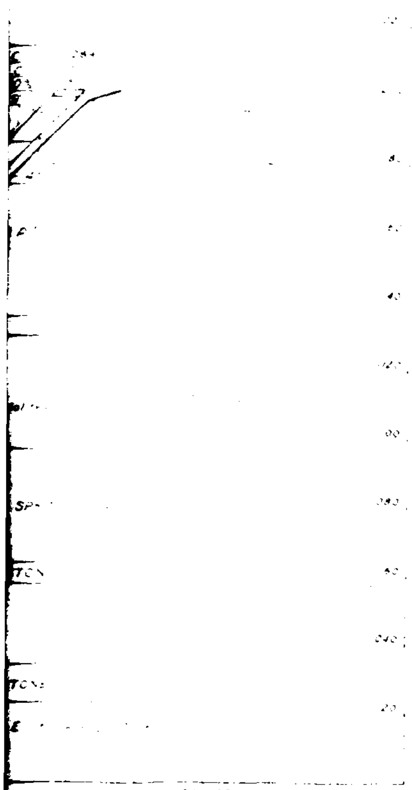
FILE NO. B-1-1030

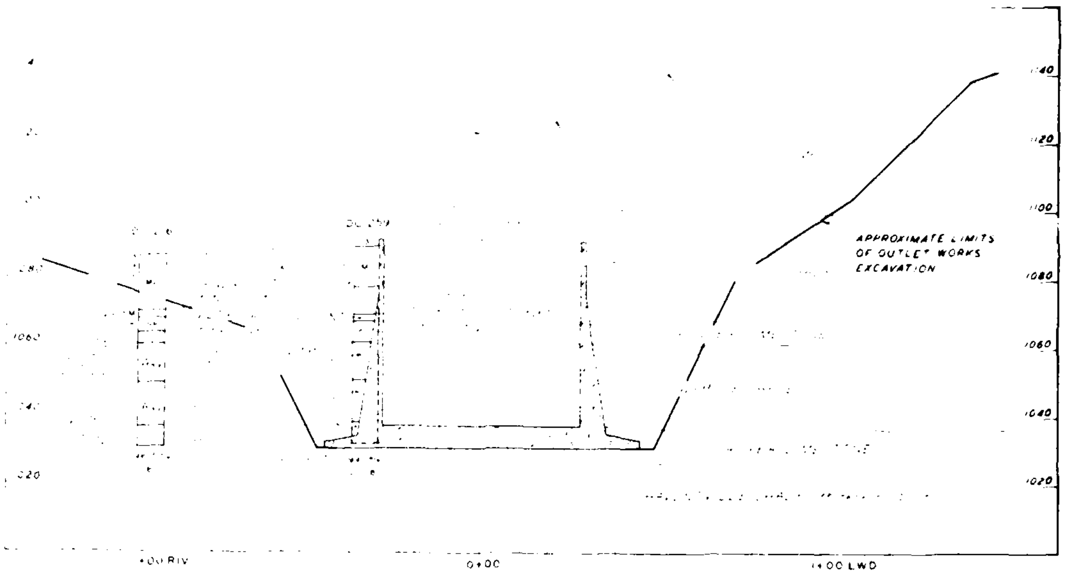
PLATE NO. 17

CONDUIT CROSS SECTION NEAR STA [illegible]

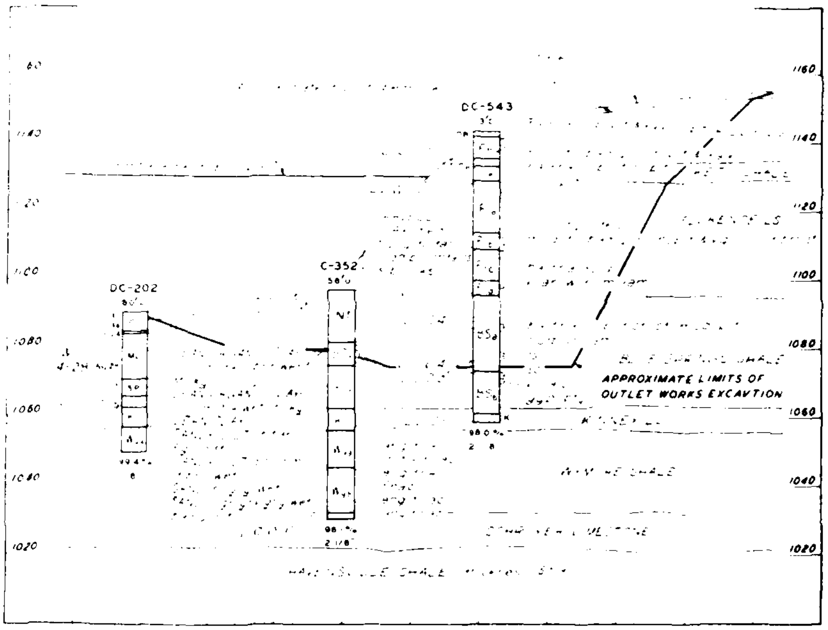


PROFILE A-A ALONG CENTERLINE OF OUTLET WORKS

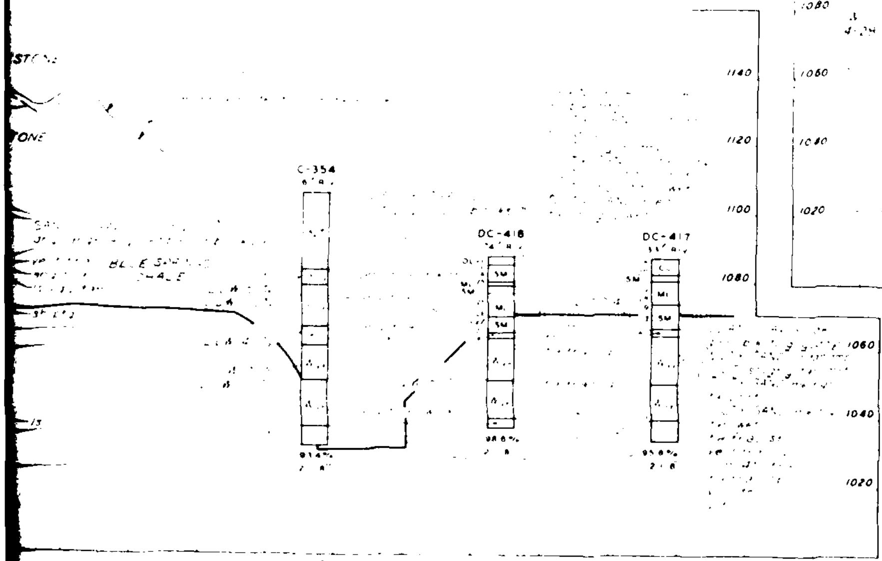




STILLING BASIN CROSS-SECTION N-N STA 5+40 D



INTAKE TOWER CROSS-SECTION L-L STA 3+10 U



OF OUTLET WORKS

SYM	DESCRIPTION	DATE	APP
	Revised for As Built conditions	6-69	
A	Changed as per Amendment No.	3-67	

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

LOGS OF EXPLORATIONS OUTLET WORKS

In 141 sheets Sheet No. 131 Scale: as shown

U. S. ARMY ENGINEER DISTRICT, KANSAS CITY

KANSAS CITY, APRIL 19

Submitted: CHIEF, GEOLOGY SECTION

Recommended: CHIEF, FOUNDATIONS & MATERIALS BR

Approved: CHIEF, ENGINEERING DIVISION

DRAWN BY J.H.S. TRACED BY R.F.M. CHECKED BY C.R.G.

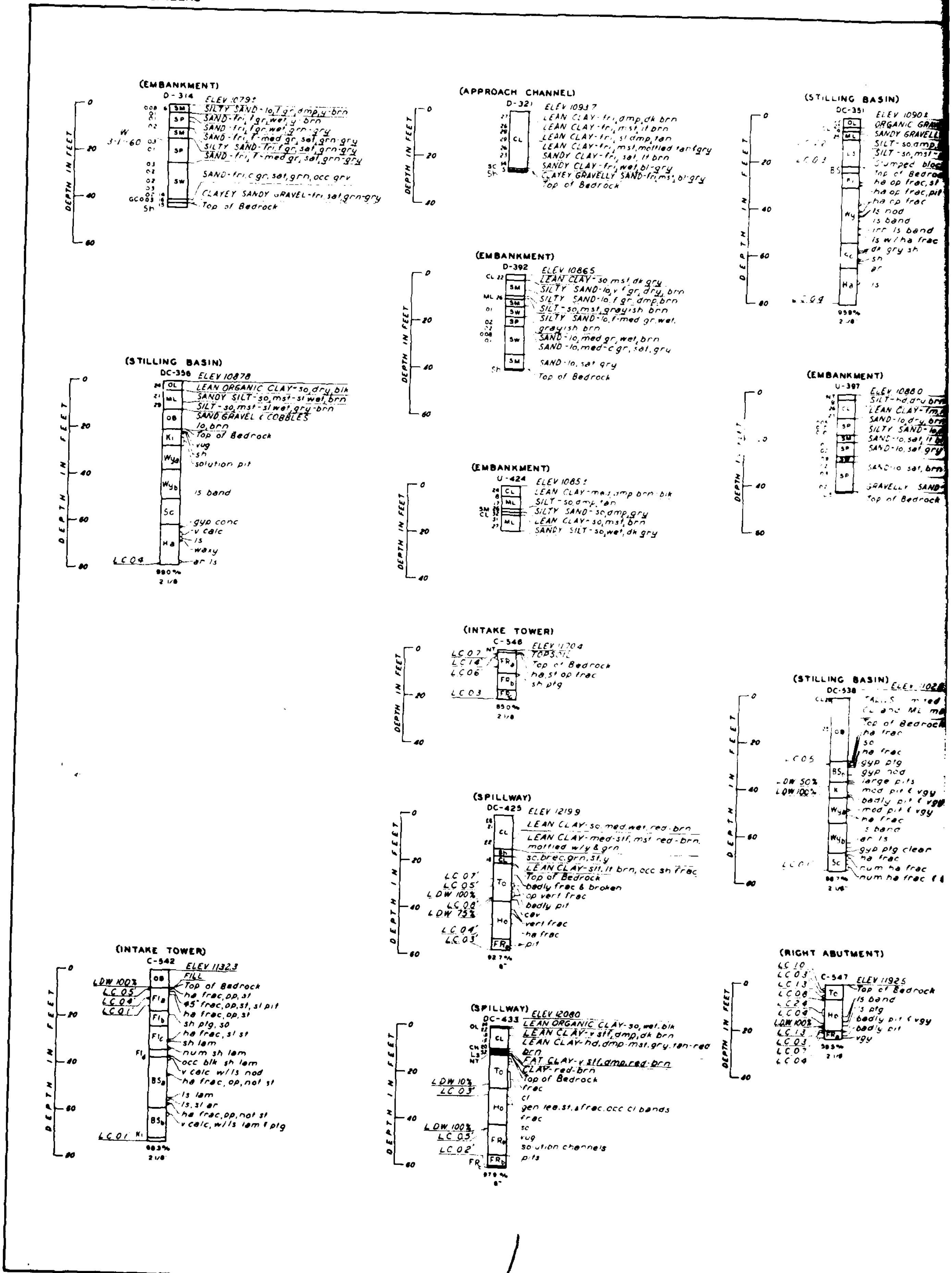
FILE NO. B-1-

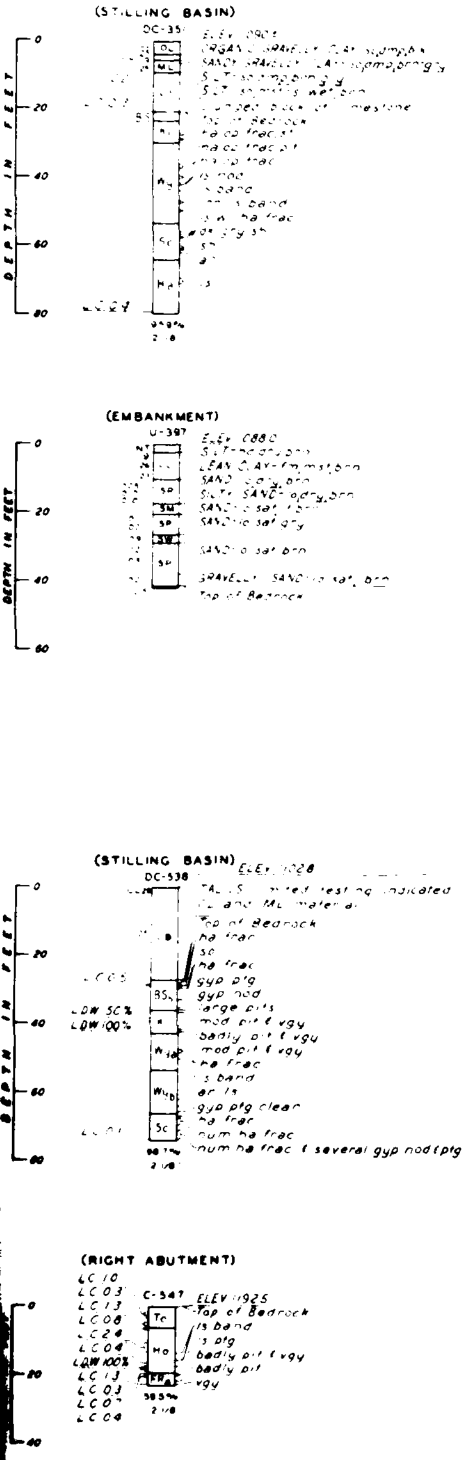
PLATE NO.

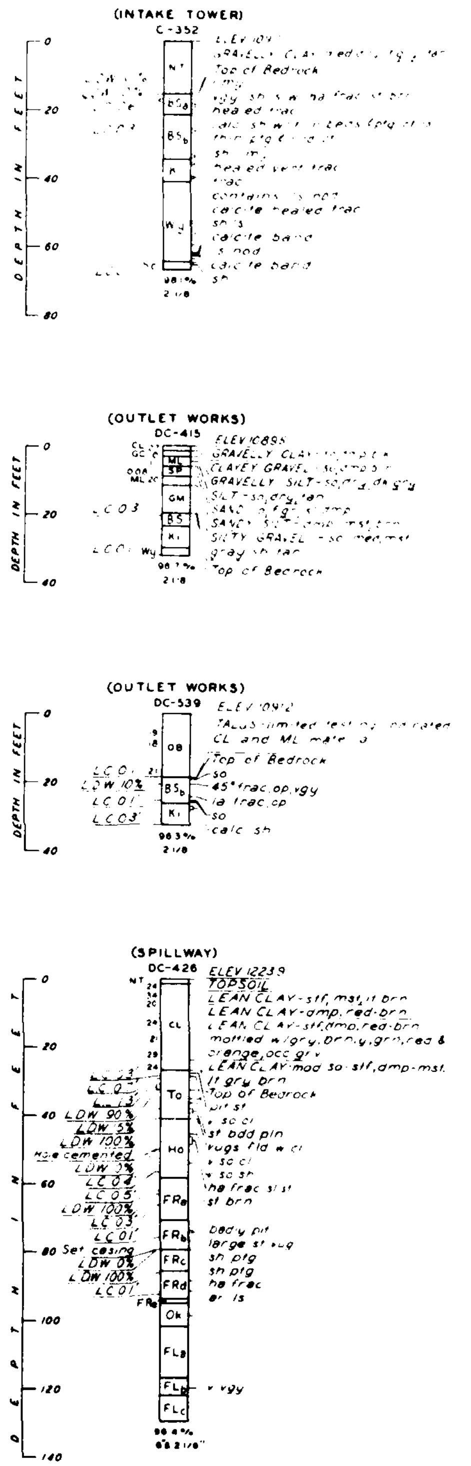
RECORD DRAWING

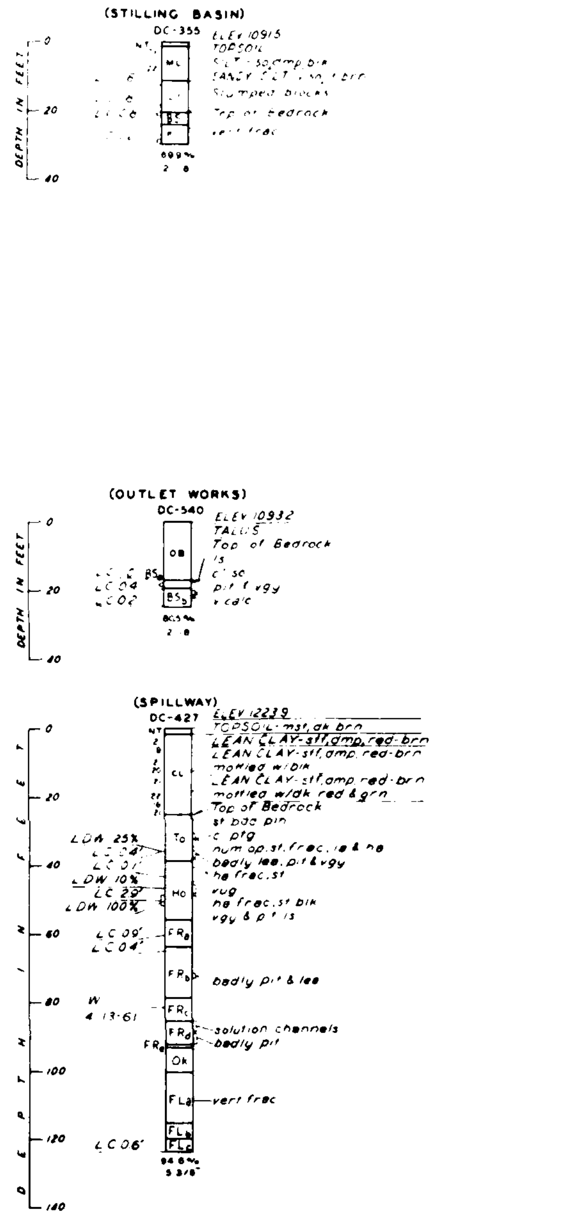
DECEMBER 1966

CONTRACT NO. DA 23 028 CIVENG 62 739


(EMBANKMENT)
D-314
ELEV 1079±
SILTY SAND-lo, f gr, dmp, y-brn
SAND-fri, f gr, wet, y-brn
SAND-fri, f gr, wet, grn-gry
SAND-fri, f-med gr, sat, grn-gry
SILTY SAND-fri, f gr, sat, grn-gry
SAND-fri, f-med gr, sat, grn-gry
SAND-fri, c gr, sat, grn, occ gry
CLAYEY SANDY GRAVEL-fri, sat, grn-gry
Top of Bedrock
DEPTH IN FEET
(APPROACH CHANNEL)
D-321
ELEV 1093.7
LEAN CLAY-fri, dmp, dk brn
LEAN CLAY-fri, mst, lt brn
LEAN CLAY-fri, sl dmp, tan
LEAN CLAY-fri, mst, mottled tan & gry
SANDY CLAY-fri, sat, lt brn
SANDY CLAY-fri, wet, bl-gry
CLAYEY GRAVELLY SAND-fri, mst, bl-gry
Top of Bedrock
(STILLING BASIN)
DC-351
ELEV 1090±
ORGANIC GRA
SANDY GRAVEL
SILT-so, dmp
SILT-so, mst
Slumped bloc
Top of Bedro
ha op frac, st
ha op frac, pit
ha op frac
ls nod
ls band
irr ls band
ls w/ha frac
dk gry sh
sh
ar
ls
(EMBANKMENT)
D-392
ELEV 1086.5
LEAN CLAY-so, mst, dk gry
SILTY SAND-lo, v f gr, dry, brn
SILTY SAND-lo, f gr, dmp, brn
SILT-so, mst, grayish brn
SILTY SAND-lo, f-med gr, wet, grayish brn
SAND-lo, med gr, wet, brn
SAND-lo, med-c gr, sat, gry
SAND-lo, sat, gry
Top of Bedrock
(STILLING BASIN)
DC-356
ELEV 1087.8
LEAN ORGANIC CLAY-so, dry, blk
SANDY SILT-so, mst-sl wet, brn
SILT-so, mst-sl wet, gry-brn
SAND, GRAVEL & COBBLES lo, brn
Top of Bedrock
vug
sh
solution pit
ls band
gyp conc
v calc
ls
waxy
ar ls
LC 04
(EMBANKMENT)
U-397
ELEV 1088.0
SILT-hd, dry, brn
LEAN CLAY-fm
SAND-lo, dry, brn
SILTY SAND-lo
SAND-lo, sat, lt
SAND-lo, sat, gry
SAND-lo, sat, brn
GRAVELLY SAND
Top of Bedrock
(EMBANKMENT)
U-424
ELEV 1085±
LEAN CLAY-med, dmp, brn-blk
SILT-so, dmp, tan
SILTY SAND-so, dmp, gry
LEAN CLAY-so, mst, brn
SANDY SILT-so, wet, dk gry
(INTAKE TOWER)
C-546
ELEV 1120.4
TOPSOIL
Top of Bedrock
ha, st op frac
sh ptg
LC 07
LC 14
LC 06
LC 03
(STILLING BASIN)
DC-538
ELEV 1026
Top of Bedrock
ha frac
so
ha frac
gyp ptg
gyp nod
large pits
med pit & vgy
badly pit & vgy
med pit & vgy
ha frac
ls band
ar ls
gyp ptg clear
ha frac
num ha frac
num ha frac
LC 05
LDW 50%
LDW 100%
(SPILLWAY)
DC-425
ELEV 1219.9
LEAN CLAY-so, med, wet, red-brn
LEAN CLAY-med-stf, mst, red-brn, mottled w/y & grn
so, brec, grn, st, y
LEAN CLAY-stf, lt brn, occ sh frac
Top of Bedrock
badly frac & broken
op vert frac
badly pit
cav
vert frac
ha frac
pit
LC 07
LC 05
LDW 100%
LC 08
LDW 75%
LC 04
LC 03
(INTAKE TOWER)
C-542
ELEV 1132.3
FILL
Top of Bedrock
ha frac, op, st
45° frac, op, st, sl pit
ha frac, op, st
sh ptg, so
ha frac, sl st
sh lam
num sh lam
occ blk sh lam
v calc w/ls nod
ha frac, op, not st
ls lam
ls, sl ar
ha frac, op, not st
v calc, w/ls lam & ptg
LDW 100%
LC 05
LC 04
LC 01
LC 01
(SPILLWAY)
DC-433
ELEV 1208.0
LEAN ORGANIC CLAY-so, wet, blk
LEAN CLAY-v stf, dmp, dk brn
LEAN CLAY-hd, dmp-mst, gry, tan-red brn
FAT CLAY-v stf, dmp, red-brn
CLAY-red-brn
Top of Bedrock
frac
cl
gen lea, st, & frac, occ cl bands
frac
sc
vug
solution channels
pits
LDW 10%
LC 03
LDW 100%
LC 05
LC 02
(RIGHT ABUTMENT)
C-547
ELEV 1192.5
Top of Bedrock
ls band
ls ptg
badly pit & vgy
badly pit
vgy
LC 10
LC 03
LC 13
LC 08
LC 24
LC 04
LDW 100%
LC 13
LC 03
LC 07
LC 04







NOTES
For legend of explorations and Generalized Geologic Column, see Sheet No 125
For other profiles, cross sections, logs of borings, see Sheet No's 125, 129 thru 131, 133 and 134
For location of borings, see Sheet No 123

SYM	DESCRIPTION	DATE	APP'D
	Revised for ...		
A	Changed as per Amendment No 1	2-26-62	

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

LOGS OF EXPLORATIONS DETACHED BORINGS

In 141 sheets — Sheet No. 132 — Scale: as shown

U. S. ARMY ENGINEER DISTRICT KANSAS CITY — KANSAS CITY, MO — APRIL 1962

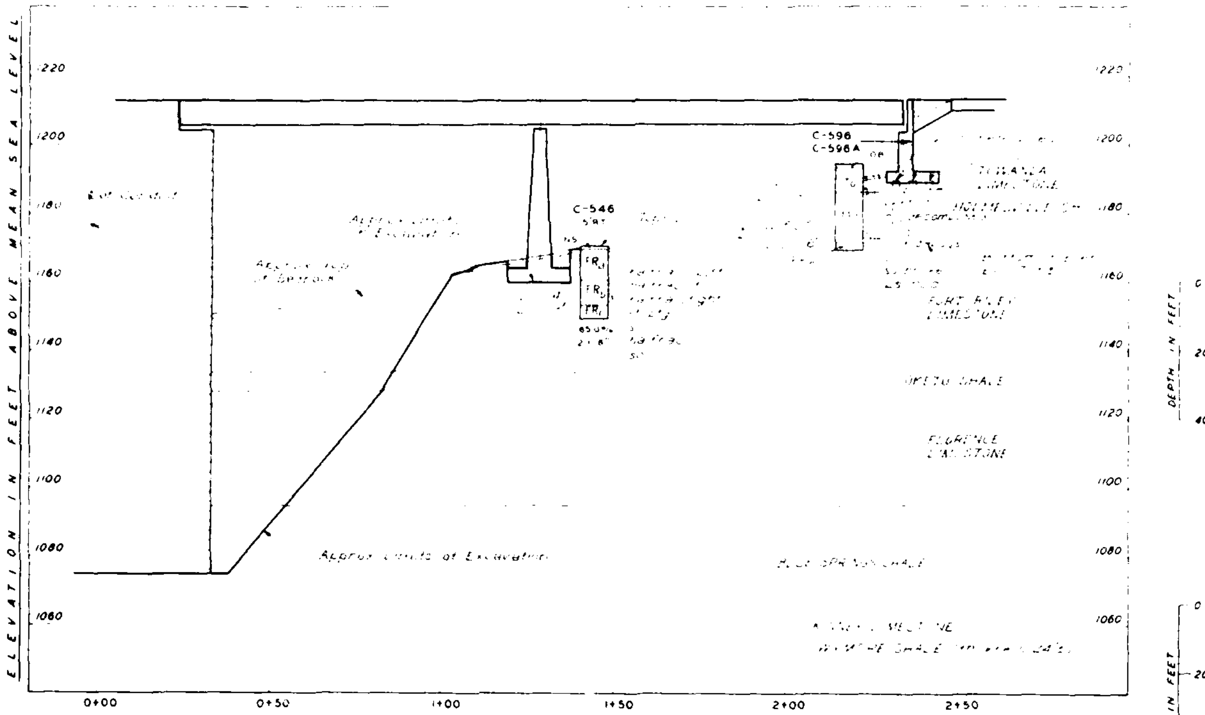
Submitted: CHIEF, GEOLOGY SECTION — Recommended: J. T. Redlinger, CHIEF, FOUNDATIONS & MATLS BR — Approved: CHIEF, ENGINEERING DIVISION

DRAWN BY J K S — TRACED BY C.E.W. — CHECKED BY C R G — FILE NO B-1-1032

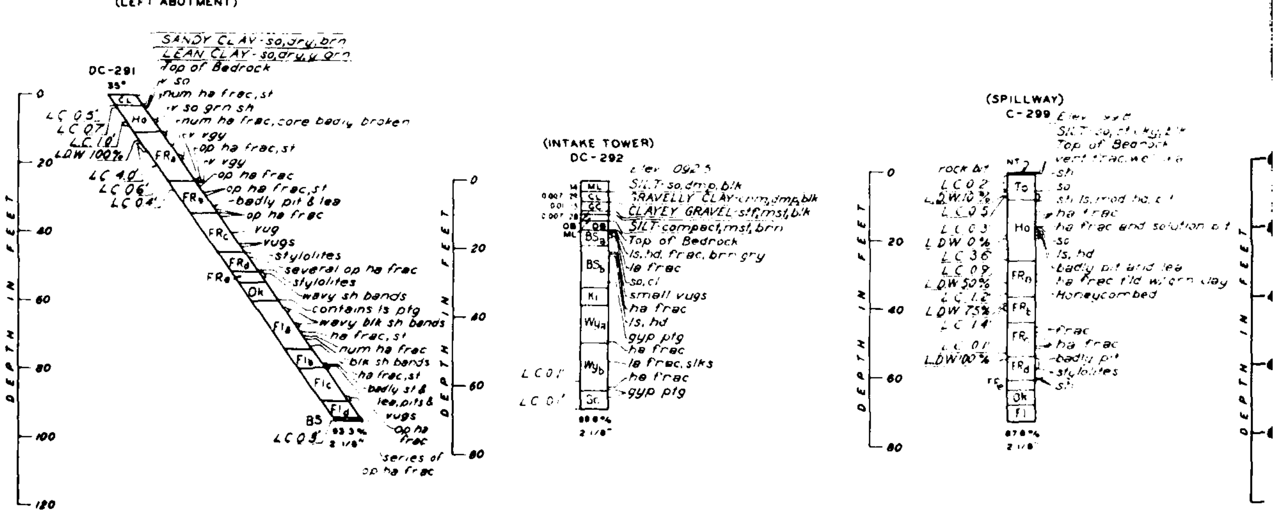
RECORD DRAWING

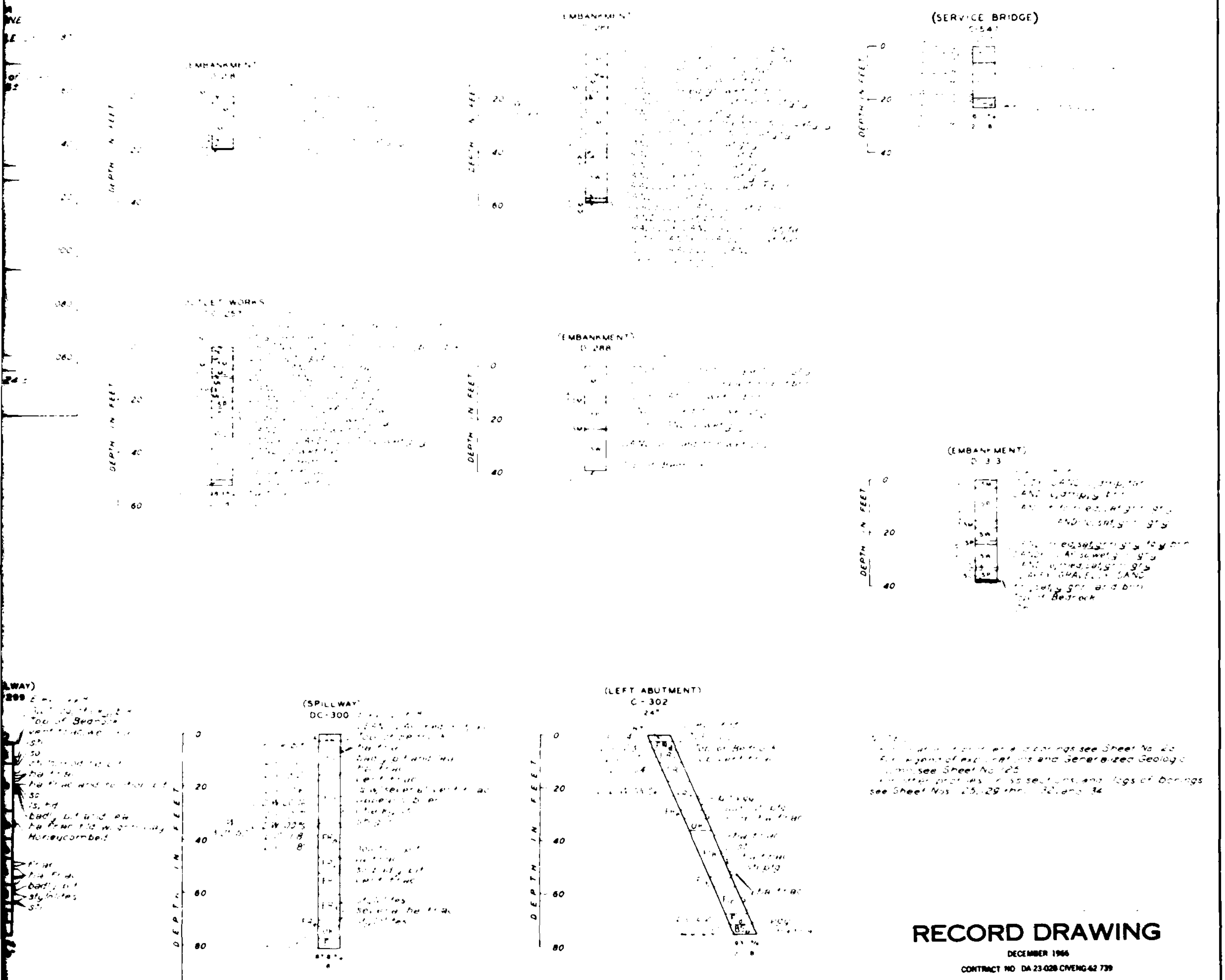
DECEMBER 1966

CONTRACT NO DA 23 028 CIVENG 62 739



PROFILE H-H-SERVICE BRIDGE





RECORD DRAWING

DECEMBER 1966

CONTRACT NO DA 23-028 CIVENG-62 739

SYM	DESCRIPTION	DATE	APP'D
A	Changed as per Amendment No1		

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

LOGS OF EXPLORATIONS DETACHED BORINGS PROFILE SERVICE BRIDGE

In 141 sheets — Sheet No 133 — Scale: as shown

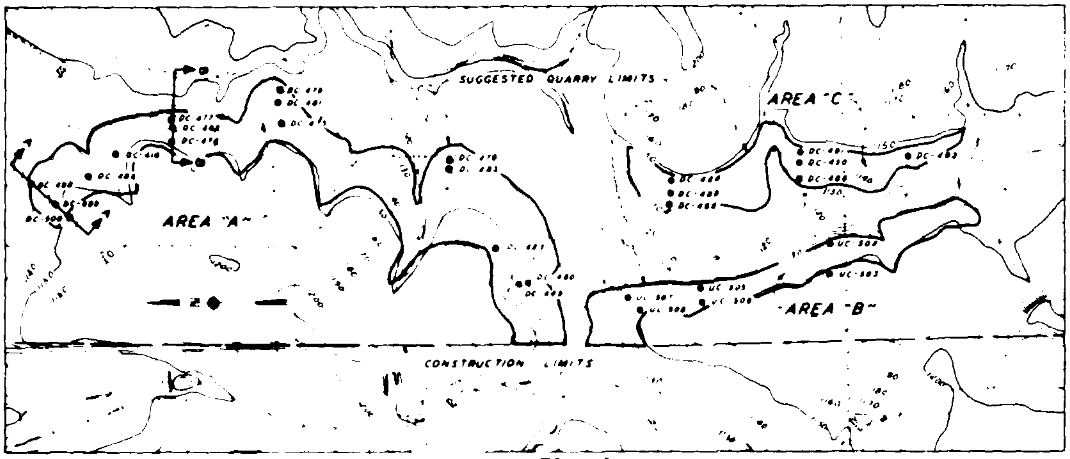
U S ARMY ENGINEER DISTRICT KANSAS CITY

KANSAS CITY, MO APRIL 1962

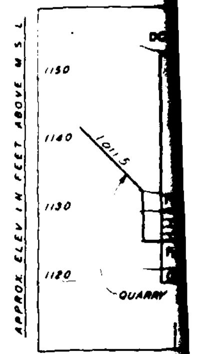
Submitted: CHIEF GEOLOGY SECTION — Recommended: CHIEF FOUNDATIONS & MATL'S BR — Approved: CHIEF ENGINEERING DIVISION

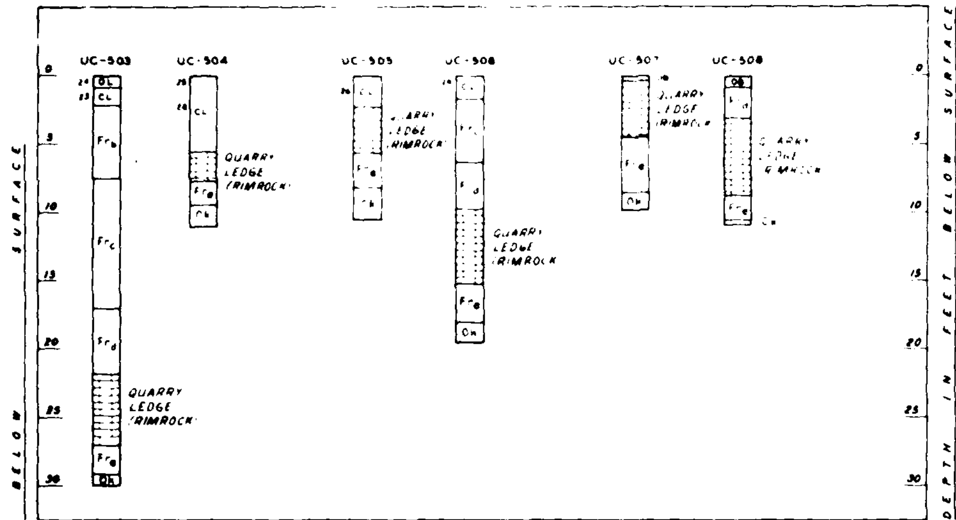
DRAWN BY J K S — TRACED BY J A W — CHECKED BY C R G — FILE NO B-1-1033

PLATE NO. 20

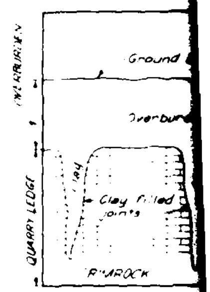


RY SITE NO I

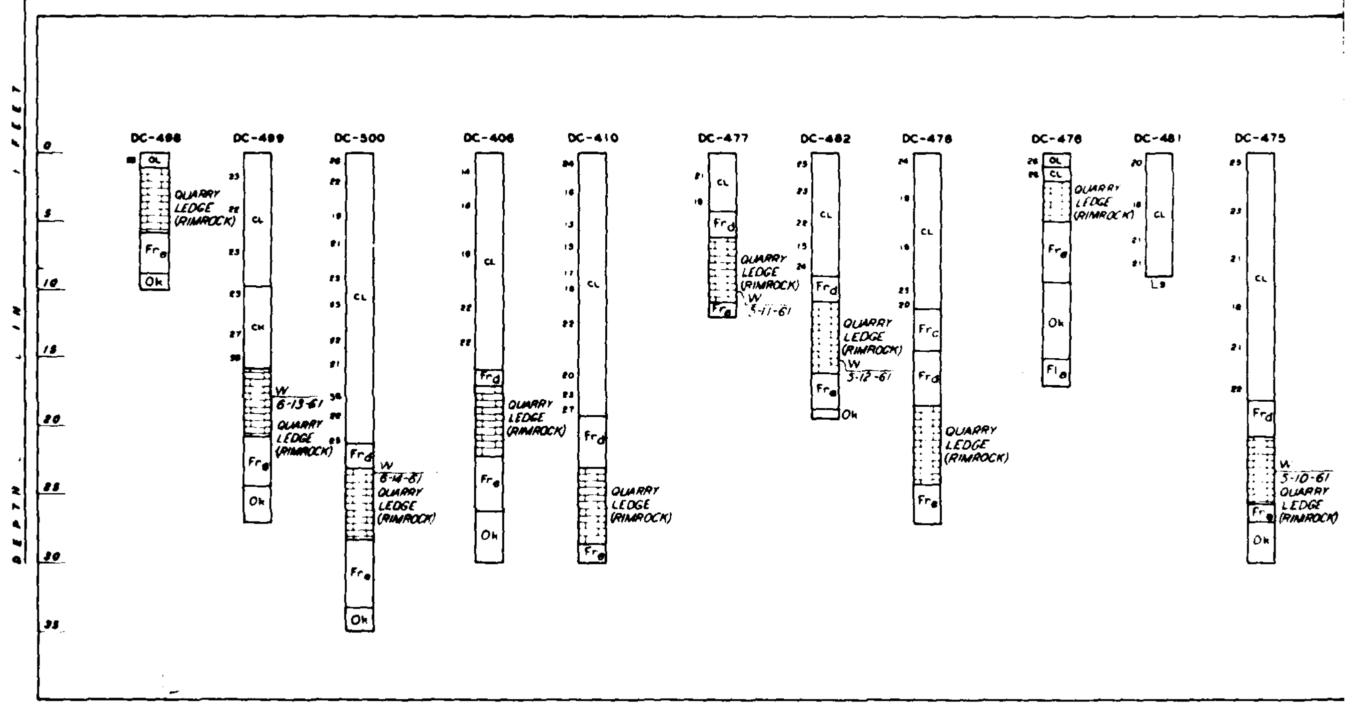




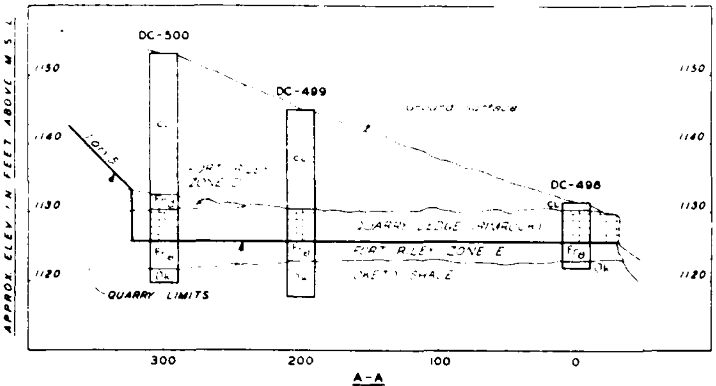
DETACHED BORINGS AREA "B"



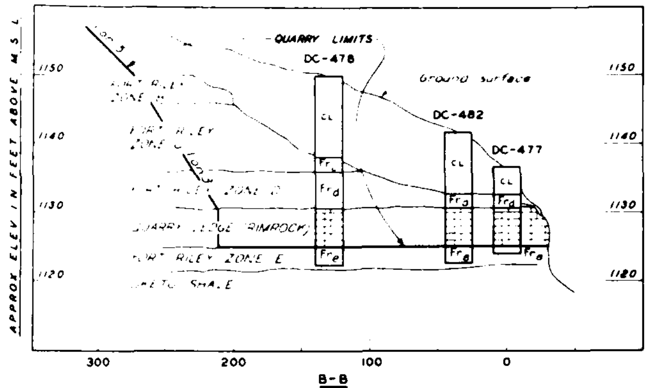
ENLARGED CLAY F



DETACHED BORINGS AREA "A"

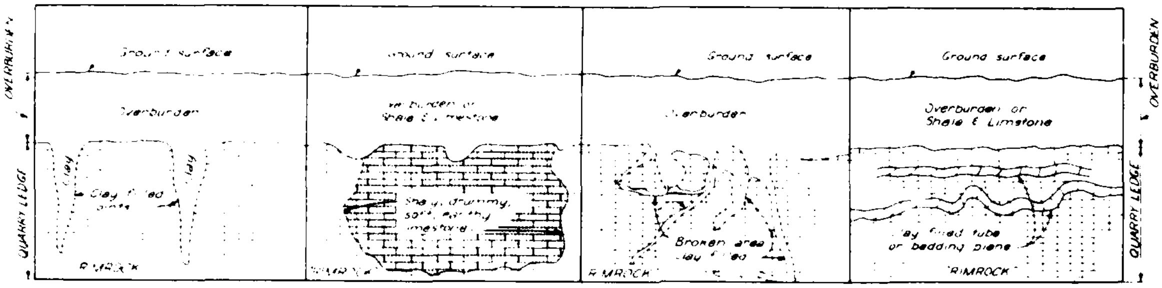


A-A



B-B

TYPICAL CROSS-SECTIONS



ENLARGED CLAY FILLED JOINTS | "SHALY"-"EARTHY"-"DRUMMY" AREAS | BROKEN CLAY FILLED ZONES | SOFT SHALY OR CLAY FILLED HORIZONTAL ZONES

TYPICAL VARIATIONS OF FORT RILEY "RIMROCK"

Not to Scale

NOTE

That section designated as rimrock and quarry ledge is also known locally as "Buildingstone Ledge", "White Ledge", "Walker Ledge", or "Junction City Limstone". Additional information on this ledge may be found in the following references; State Geological Survey of Kansas Bulletin 39 page 77, "The Geology of Riley and Geary Counties" and State Geological Survey of Kansas Bulletin 89 page 44 "The Kansas Rock Column".

Limits as shown are suggested working limits for quarry operations and are subject to change depending upon quality of materials encountered.

The variations shown are diagramatic variations which may be encountered.

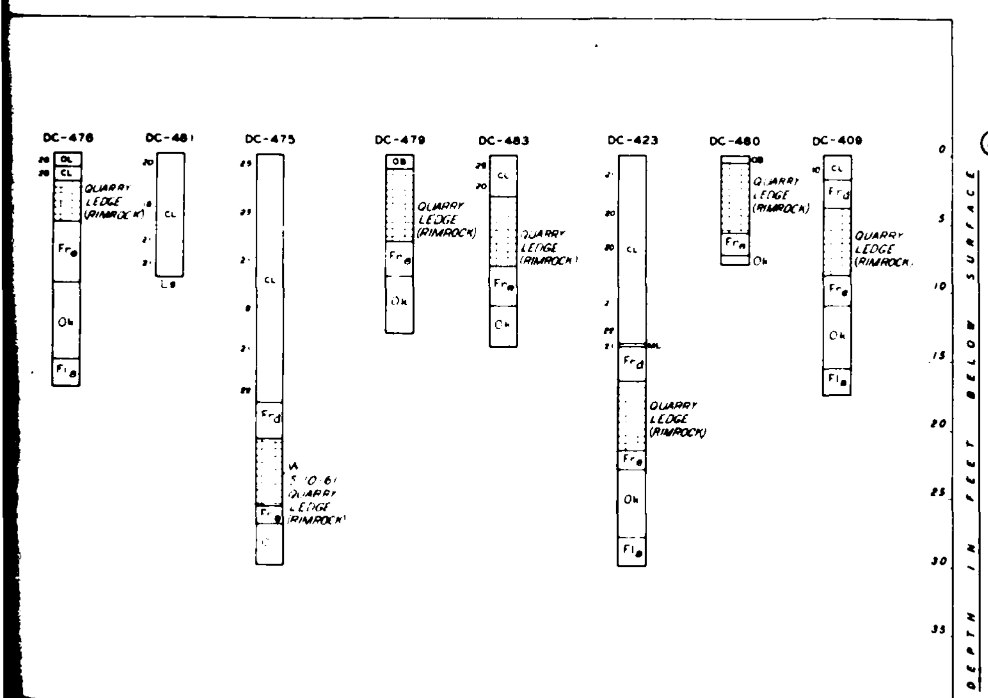
The Quarry Ledge or Rimrock as shown is the lower 5.5' of the d zone of the Fort Riley Limestone.

For location of the Quarry Site with reference to dam axis, see Sheet No 124.

For general geologic description of bedrock zones and explanation of symbols, see Sheet No 125.

Detailed logs of borings are available for inspection in the Kansas City, Corps of Engineers District Office.

(A) Area-A to be used by Schedule II Contractor for production of riprap, Area-B Schedule II Contractor will remove overburden and rock material for the Schedule III Contractor, Area-C this area will be utilized for the production of riprap only by approval of the contracting officer.



AREA "A"

RECORD DRAWING

DECEMBER 1966

CONTRACT NO DA-23-028-CIVENG-62-730

SYM	DESCRIPTION	DATE	APP'D.
	Revised for "As Built" conditions	5-6-65	
(A)	Changed as per Amendment No 1	7-20-62	
REVISIONS			

REPUBLICAN RIVER, KANSAS

MILFORD DAM

QUARRY SITE NO.1

In 141 sheets — Sheet No. 134 — Scale: as shown

U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

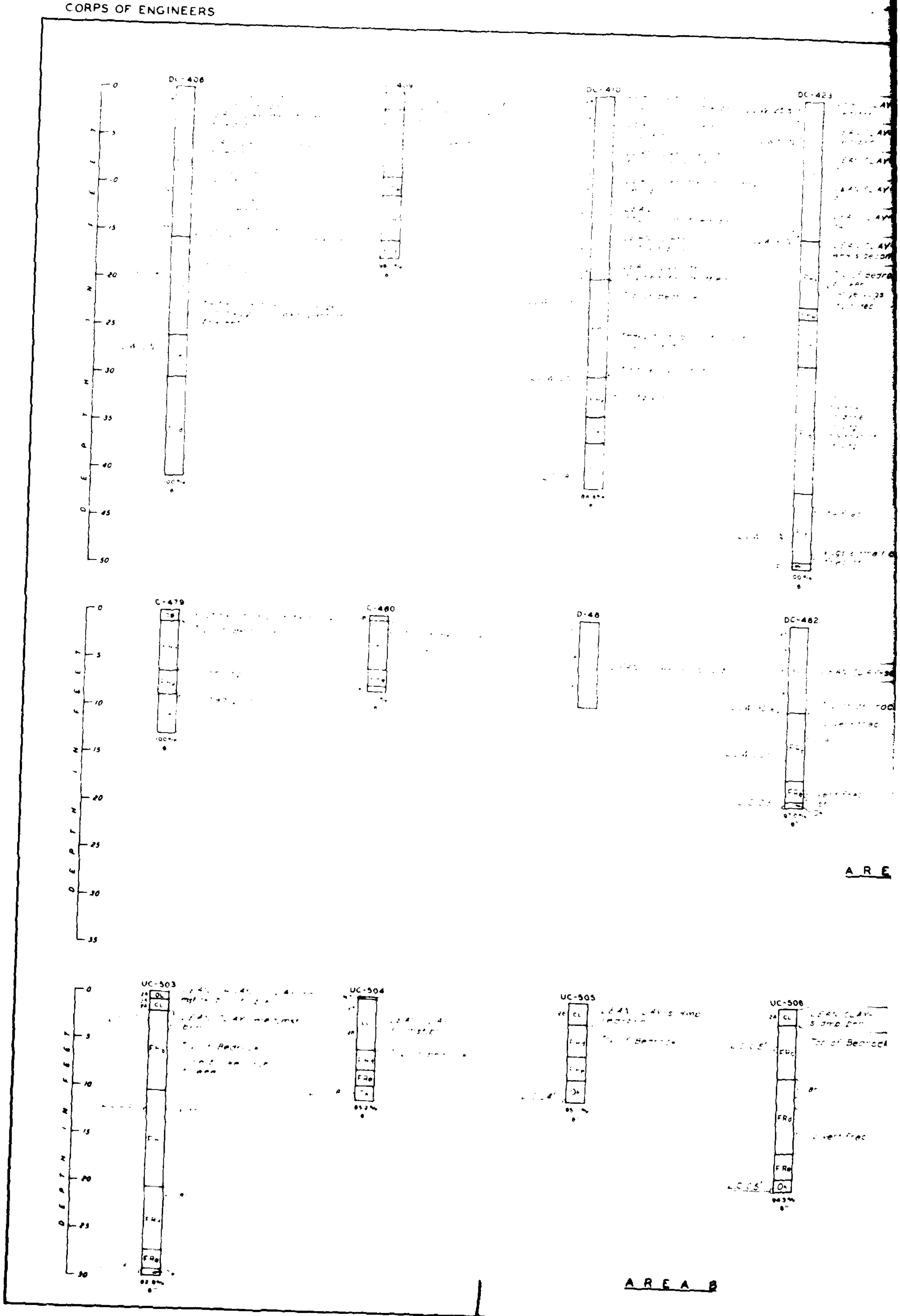
KANSAS CITY, MO
APRIL 1962

Submitted: CHIEF, GEOLOGY SECTION
Recommended: CHIEF, FOUNDATIONS & MATLS BR
Approved: CHIEF, ENGINEERING DIVISION

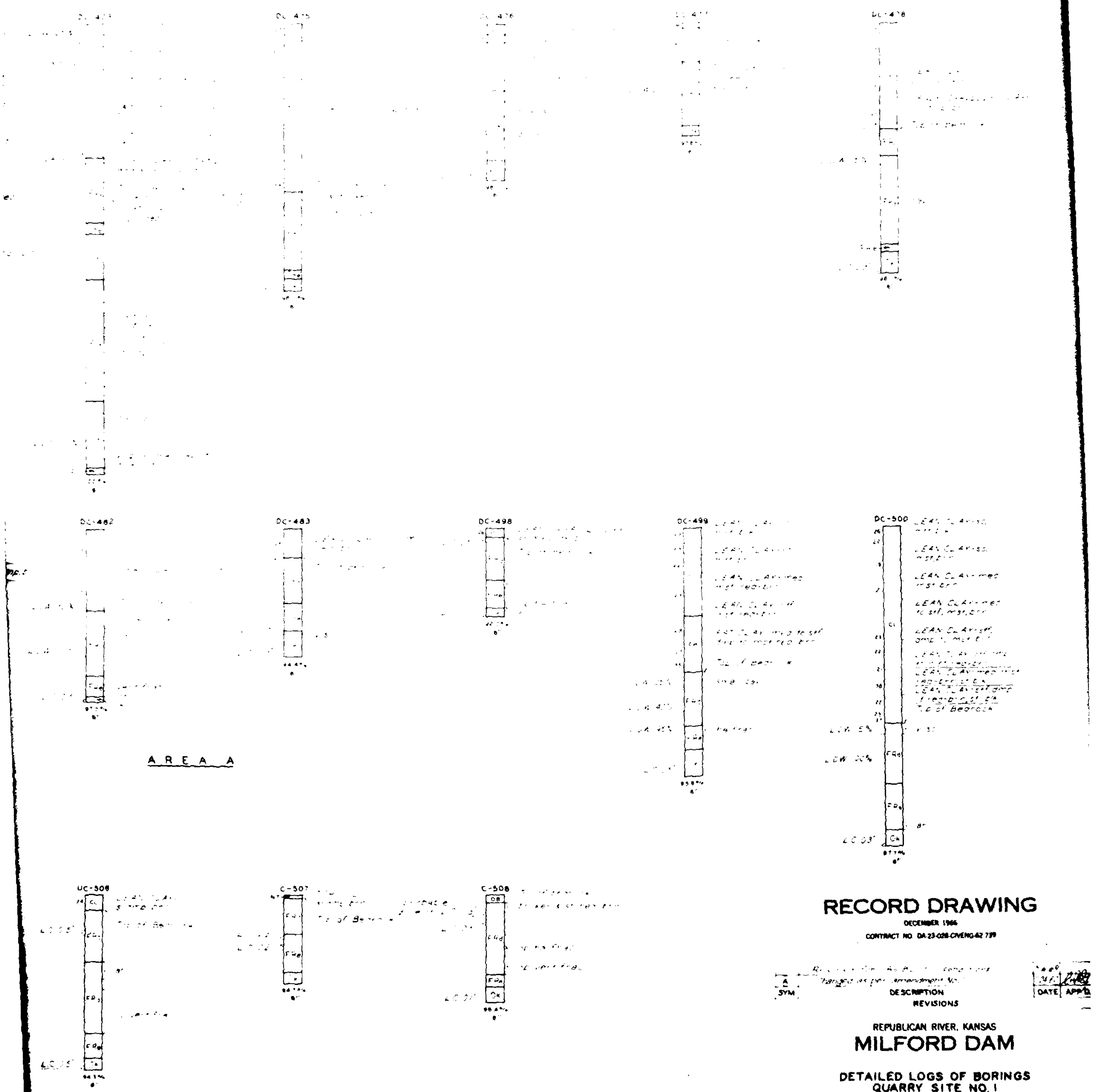
DRAWN BY S.D.M. — TRACED BY J.R.P. — CHECKED BY C.R.G. — FILE NO. B-1-1034

PLATE NO. 21

CORPS OF ENGINEERS



U S ARM



RECORD DRAWING

DECEMBER 1966

CONTRACT NO. DA-23-028-CIVENG-62 739

SYM	DESCRIPTION	DATE	APP'D
A	Revised ... As Built ... conditions. Changed as per amendment No.		

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

DETAILED LOGS OF BORINGS QUARRY SITE NO. 1

In 141 sheets | Sheet No. 135 | Scale: as shown

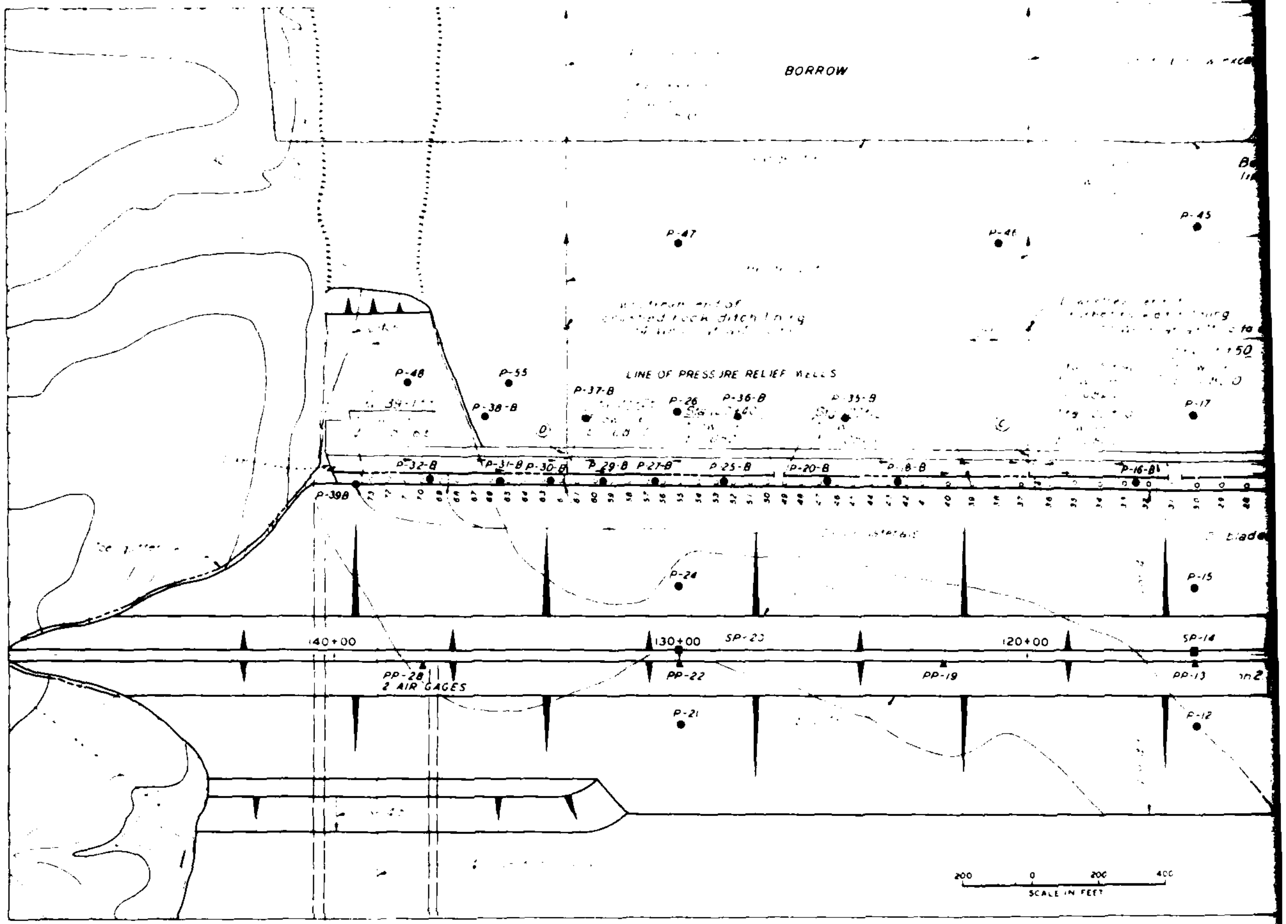
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

KANSAS CITY, MO.
MAY 1962

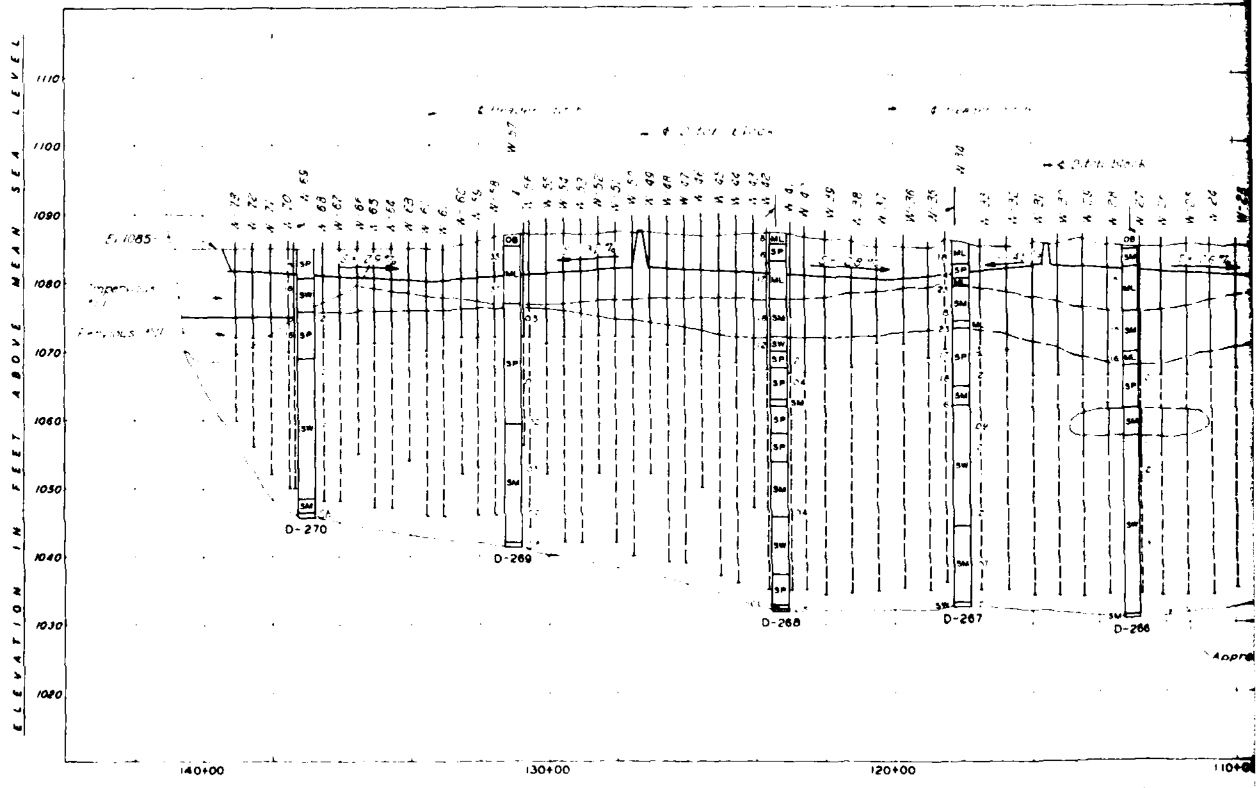
Submitted: CHIEF, GEOLOGY SECTION
Recommended: CHIEF, FOUNDATIONS & MATLS BR
Approved: CHIEF, ENGINEERING DIVISION

DRAWN BY H.R.L. | TRACED BY R.F.M. | CHECKED BY C.R.G. | FILE NO. B-1-1038

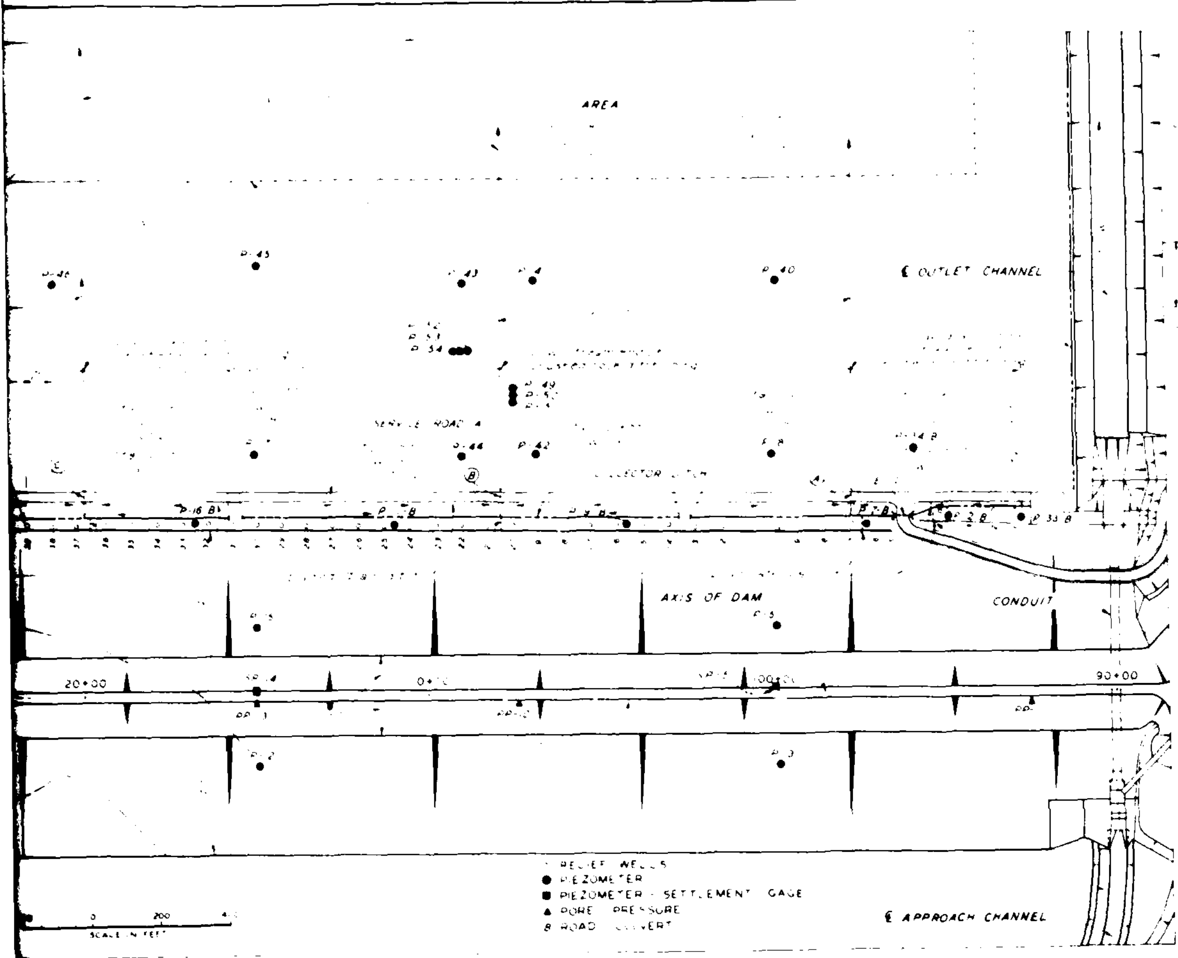
PLATE NO. 2



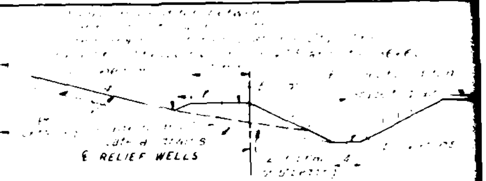
PLAN OF RELIEF WELLS AND OBSERVATION DEV



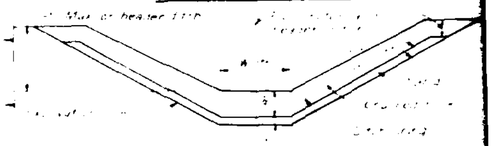
PROFILE ALONG LINE OF WELLS



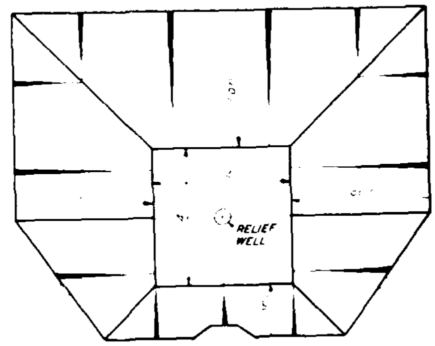
WELLS AND OBSERVATION DEVICES



TYPICAL SECTION THRU RELIEF WELL LINE

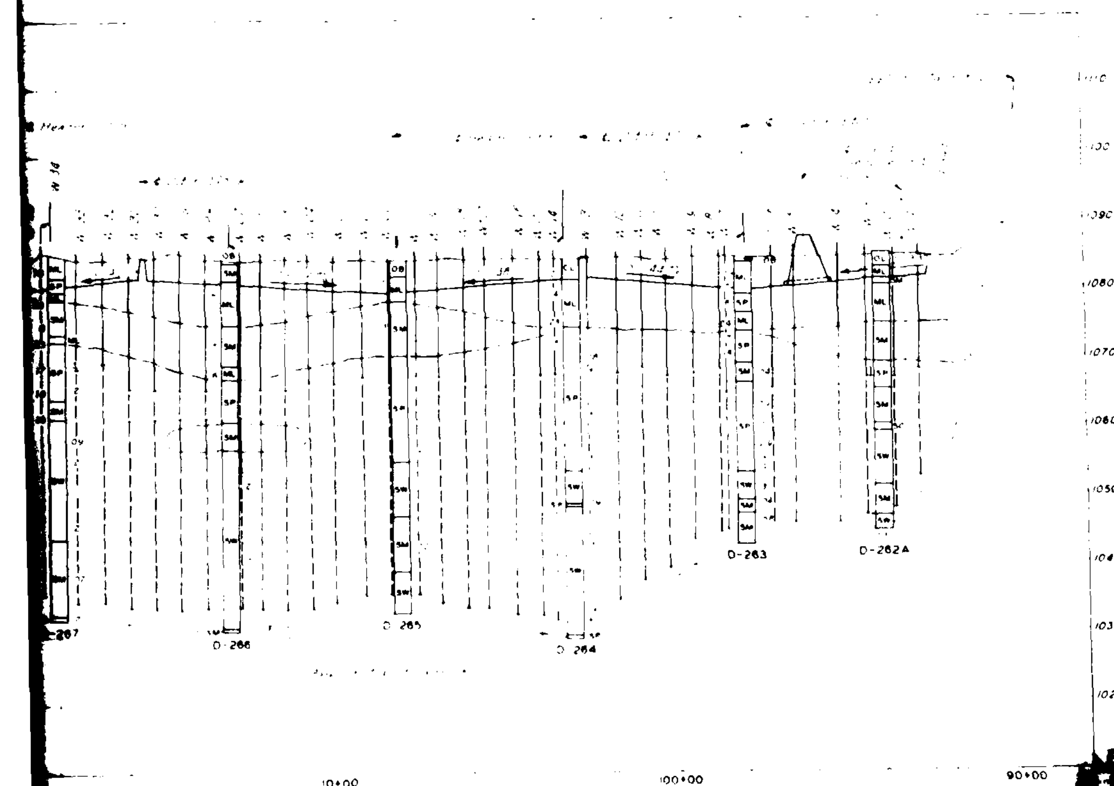


TYPICAL DITCH SECTION



TYPICAL PLAN

EXCAVATION AND BACKFILL



ALONG LINE OF WELLS

RECORD DRAWING

DECEMBER 1966

CONTRACT NO DA 23-028-CIVENG-62 739

SYM	DESCRIPTION	DATE
	Revised ...	
B	Revision of Relief Well Details	
A	Changed as per Amendment ...	

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

RELIEF WELLS PLAN AND PROFILE

In 141 sheets — Sheet No 18 — Scale: as shown

U S ARMY ENGINEER DISTRICT KANSAS CITY — KANSAS CITY, MO. APRIL 19..

Submitted: CHIEF ... SECTION — Recommended: CHIEF FOUNDATIONS & MATLS BR — Approved: CHIEF ENGINEERING DIVISION

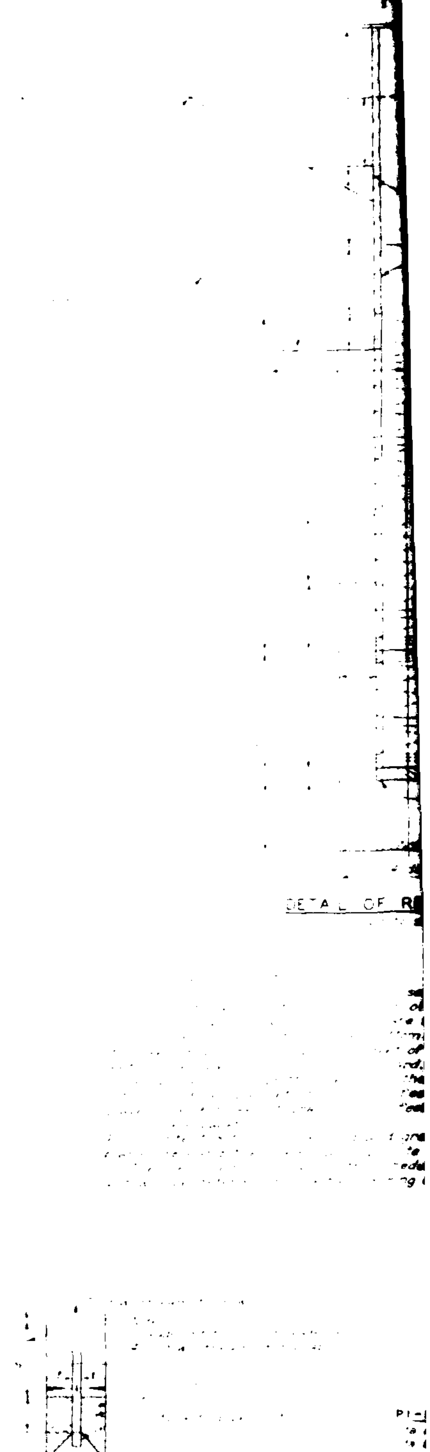
DRAWN BY C G F — TRACED BY W D T — CHECKED BY R L E

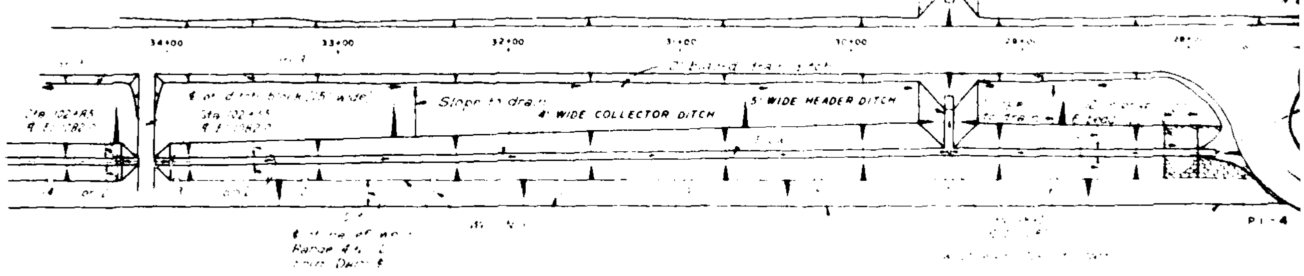
PLATE NO.

CORPS OF ENGINEERS

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	8.	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	8.	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	.0822	[illegible]	[illegible]	[illegible]
34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
40	22+5?	8.0	[illegible]	[illegible]	[illegible]	[illegible]
42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
43	24+24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
44	24+54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
48	26+?	[illegible]	.082?	[illegible]	[illegible]	[illegible]
49	27+?	[illegible]	.0825	[illegible]	[illegible]	[illegible]
50	[illegible]	[illegible]	.0824	32.8	[illegible]	[illegible]
51	[illegible]	[illegible]	.0823	4?.?	[illegible]	[illegible]
52	[illegible]	[illegible]	.082?	36.?	[illegible]	[illegible]
53	29+2?	[illegible]	.08?9	44.?	[illegible]	[illegible]
54	29+5?	[illegible]	[illegible]	45.?	[illegible]	[illegible]
55	[illegible]	[illegible]	.08?6	[illegible]	[illegible]	[illegible]
56	32+5?	[illegible]	.08?4	4?	[illegible]	[illegible]
57	[illegible]	[illegible]	.08?3	[illegible]	[illegible]	[illegible]
58	3?+54	8.0	.081?	46.?	[illegible]	[illegible]
59	32+24	[illegible]	.08??	4?.8	[illegible]	[illegible]
60	32+5?	8.0	.0808	[illegible]	[illegible]	[illegible]
61	33+0?	8.0	.0806	4?	[illegible]	[illegible]
62	33+54	?.0	.080?	44.?	[illegible]	[illegible]
63	34+0?	8.0	.0807	[illegible]	[illegible]	[illegible]
64	34+2?	8.0	.0808	4?	[illegible]	[illegible]
65	35+06	8.0	.0809	44	[illegible]	?4
66	35+56	8.?	.081?	34.8	[illegible]	[illegible]
67	36+25	8.0	.0812	45.4	25.?	?2.8
68	36+5?	?.0	.0814	45.?	[illegible]	[illegible]
69	37+?6	8.0	.0815	46.?	[illegible]	[illegible]
70	37+55	6.0	.081?	45.?	[illegible]	[illegible]
71	38+06	6.?	.0818	4?.?	[illegible]	[illegible]
72	38+5?	6.0	.0820	44	[illegible]	[illegible]
73	39+06	6.0	.082?	38.?	2?.8	8.9

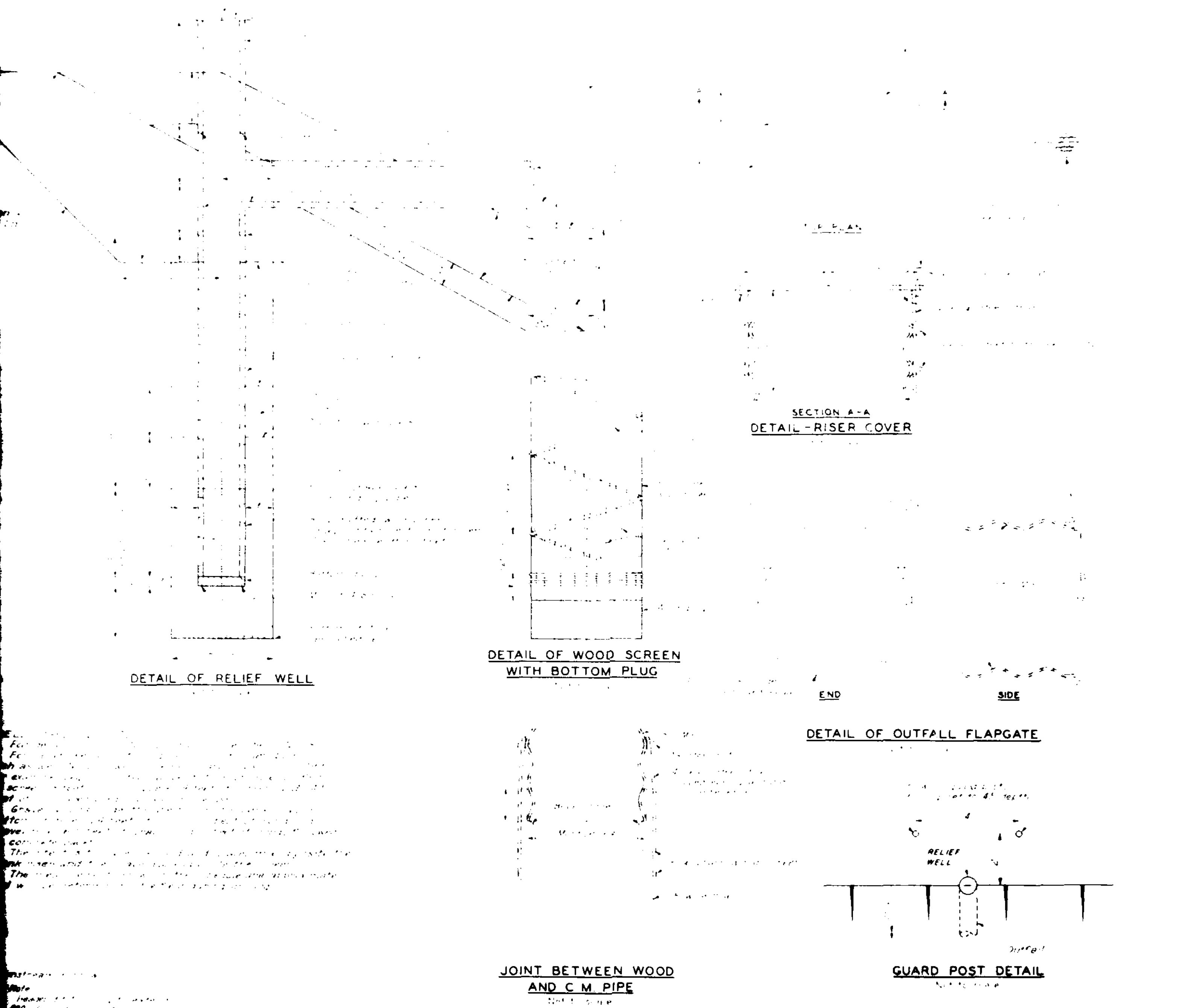
WELL SCHEDULE

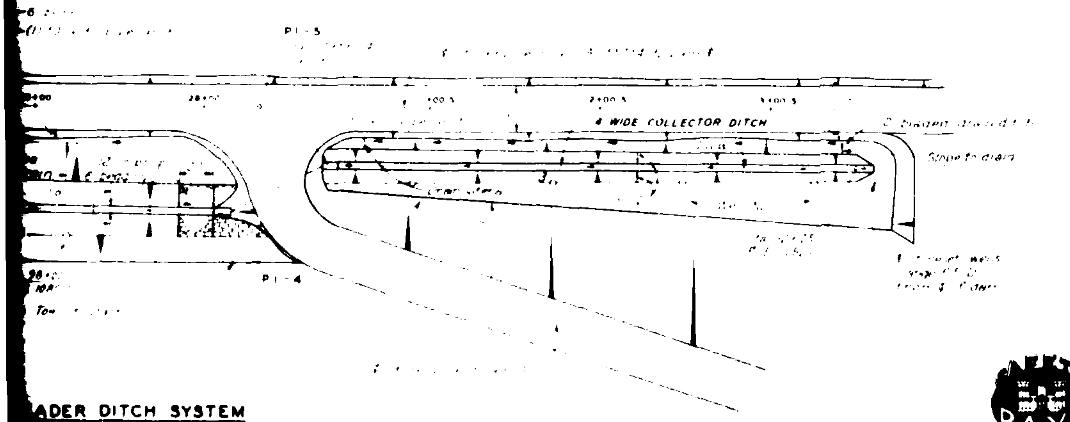




PLAN-TYPICAL COLLECTOR AND HEADER DITCH SYSTEM

J.S. ARMY





RECORD DRAWING

DECEMBER 1966

CONTRACT NO DA 23-028-CIVENG-62-739

SYM	DESCRIPTION	DATE	APP'D
B	Revision of Relief Well Details		
A	Changed as per Amendment No		

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

RELIEF WELLS SCHEDULE AND DETAILS

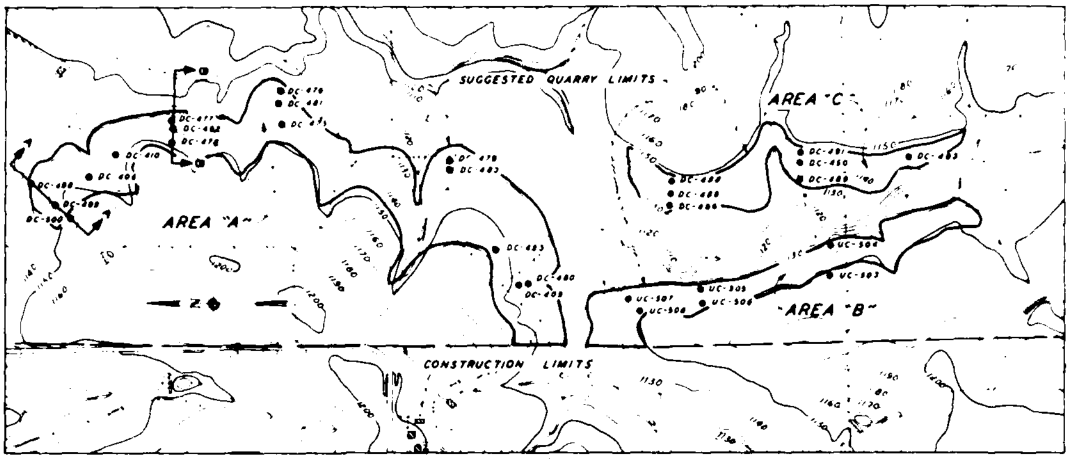
In 141 sheets — Sheet No. 1 — Scale: as shown

U. S. ARMY ENGINEER DISTRICT, KANSAS CITY — KANSAS CITY, MO — APRIL 1962

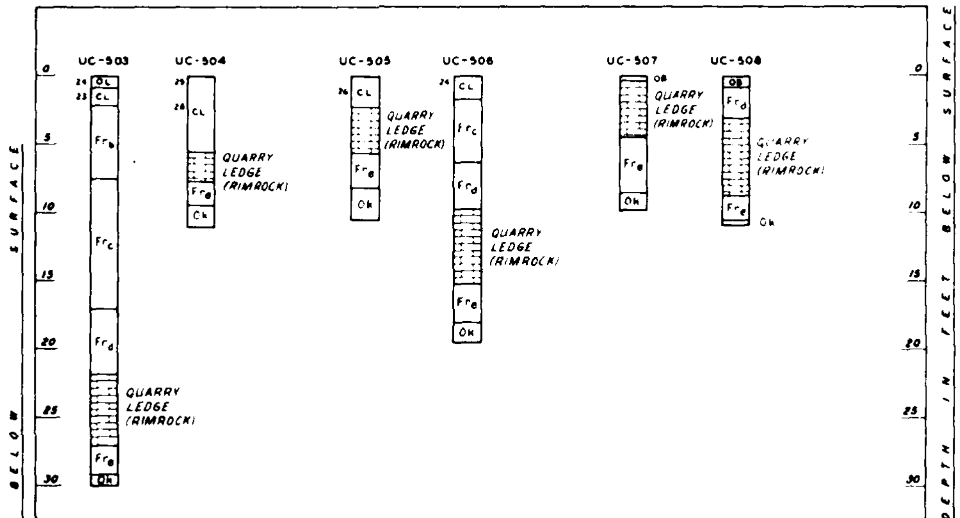
Submitted: CHIEF, ... SECTION — Recommended: J. T. Redlinger, CHIEF, FOUNDATIONS & MATLS BR — Approved: CHIEF, ENGINEERING DIVISION

DRAWN BY: C G — TRACED BY: J A W — CHECKED BY: R L B — FILE NO: B-1-917

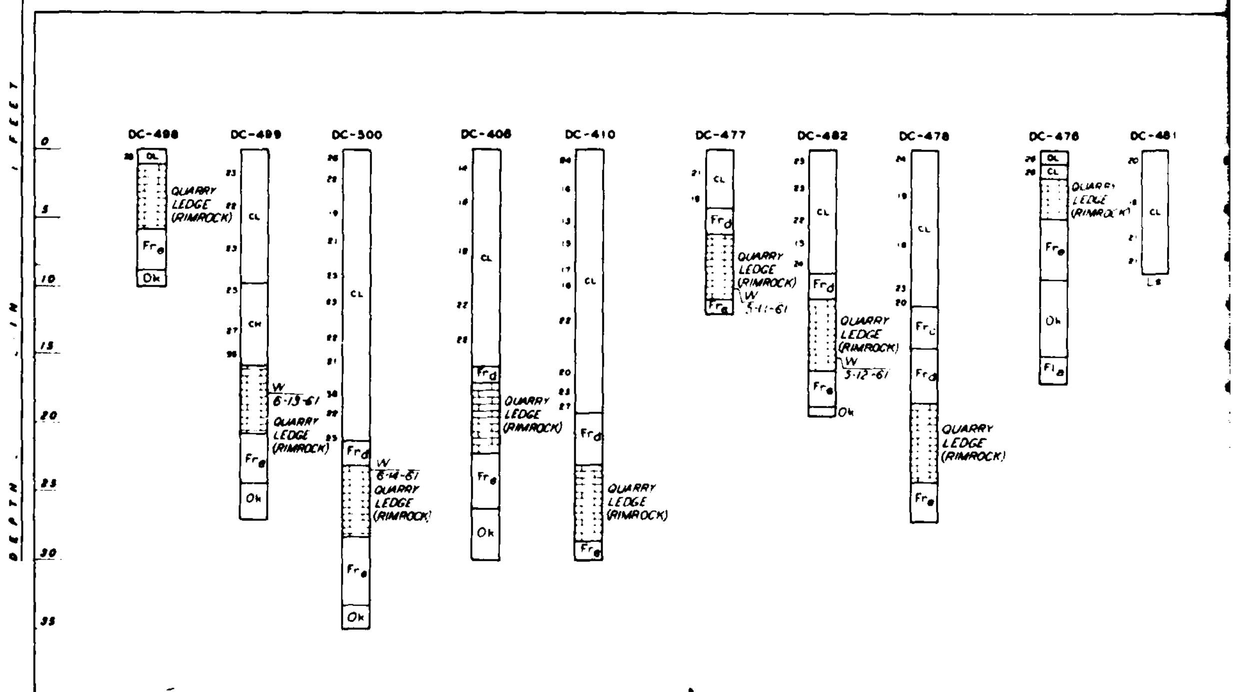
PLATE NO. 24



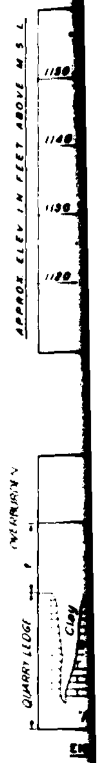
QUARRY SITE NO. I
Scale 1" = 400'

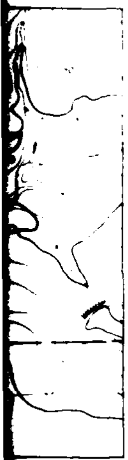


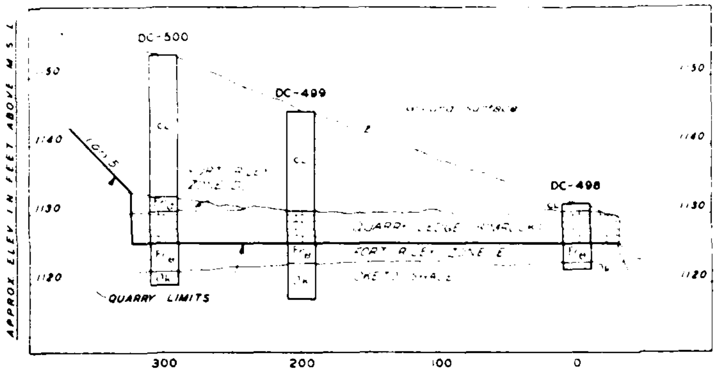
DETACHED BORINGS AREA "B"



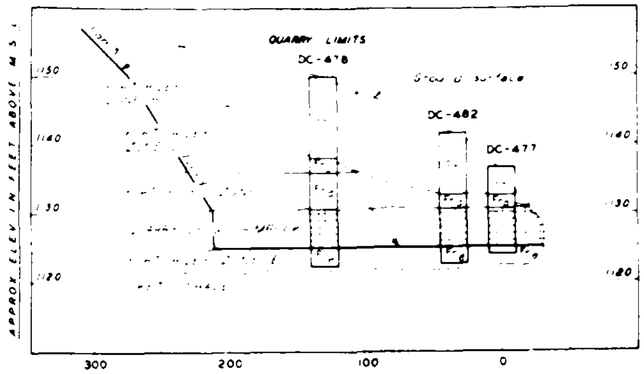
DETACHED BORINGS AREA "A"





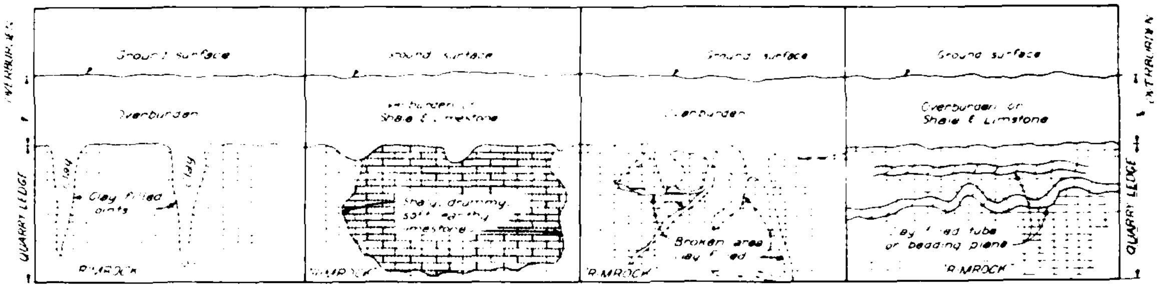


A-A



B-B

TYPICAL CROSS-SECTIONS



ENLARGED CLAY FILLED JOINTS | "SHALY"-"EARTHY"-"DRUMMY" AREAS | BROKEN CLAY FILLED ZONES | SOFT SHALY OR CLAY FILLED HORIZONTAL ZONES

TYPICAL VARIATIONS OF FORT RILEY "RIMROCK"

Not to Scale

NOTE

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The variations shown are diagramatic variations which may be encountered.

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For general geologic description of bedrock zones and explanation of symbols, see Sheet No 125.

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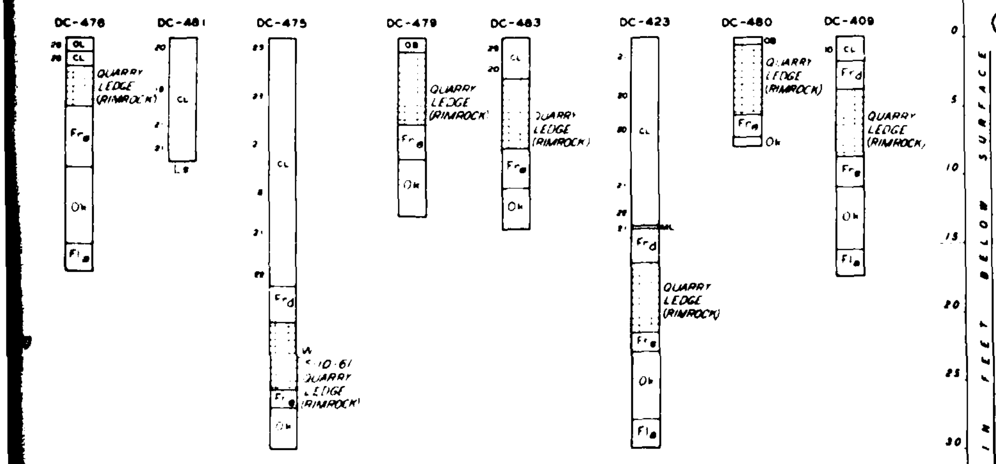


AREA "A"

RECORD DRAWING

DECEMBER 1966

CONTRACT NO DA-23-028-CIVENG-62-730

SYM	DESCRIPTION	DATE	APP'D.
	Revised for "As Built" conditions	5-6-65	
(A)	Changed as per Amendment No.1		

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD DAM

QUARRY SITE NO.1

In 141 sheets
U. S. ARMY ENGINEER DISTRICT
KANSAS CITY

Sheet No. 134

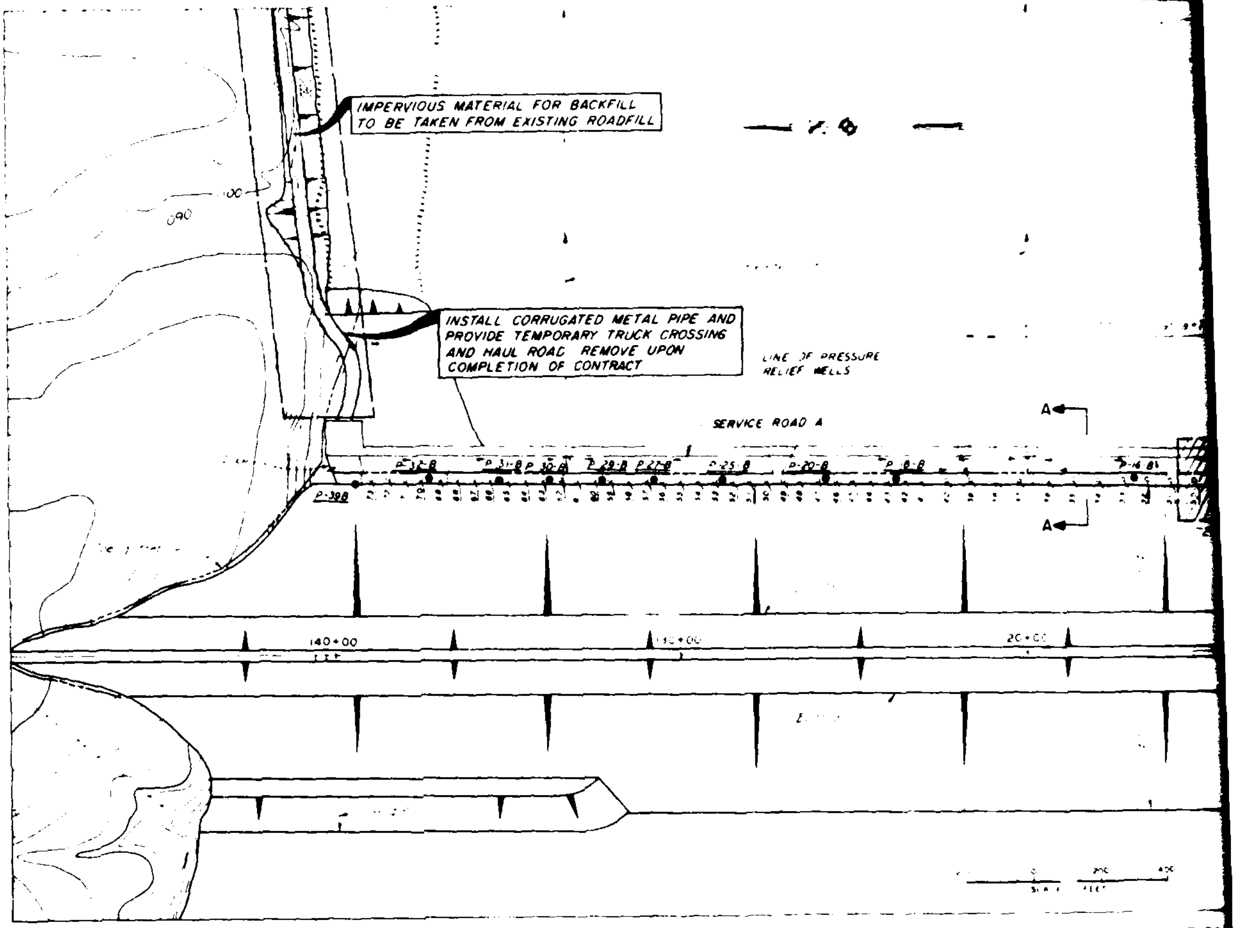
Scale: as shown
KANSAS CITY, MO
APRIL 1962

Submitted: Chief Geology Section
Recommended: J. T. Redlinger, Chief Foundations & Mat'ls Br
Approved: Chief, Engineering Division

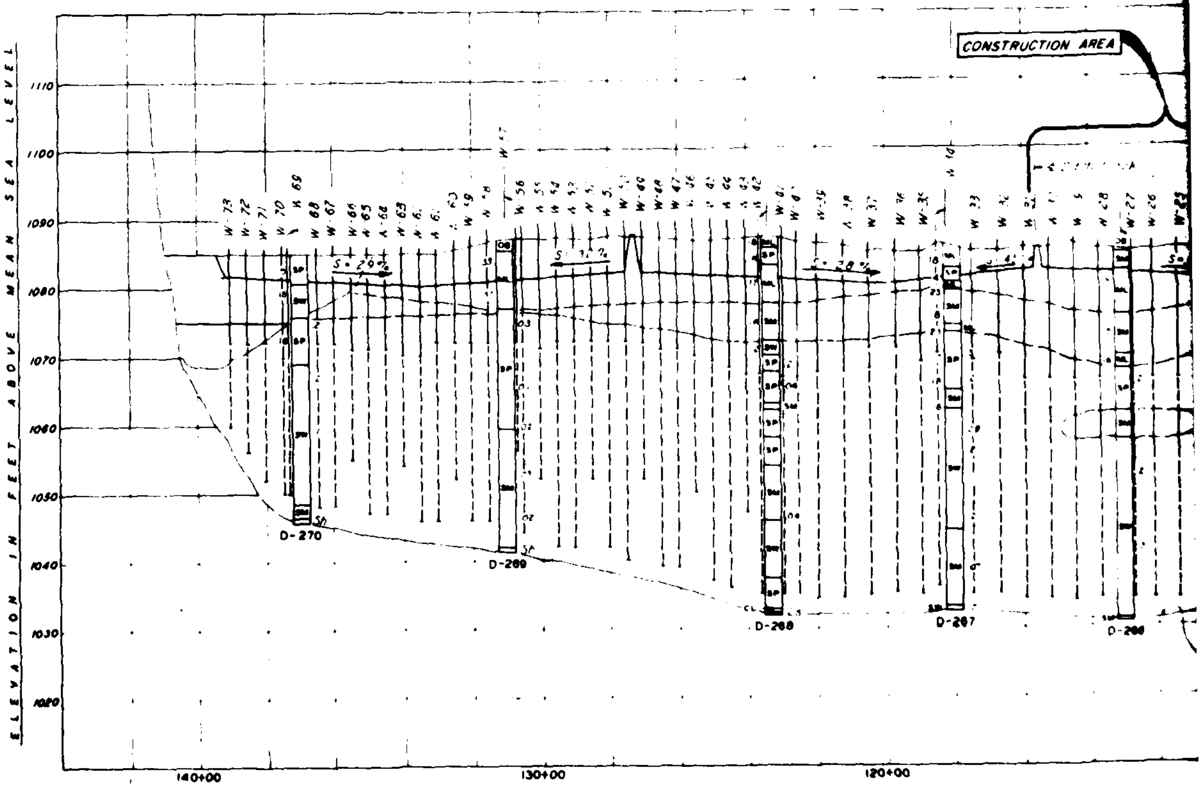
Drawn by: S.D.M
Traced by: J.R.P.
Checked by: C.R.G

File No: B-1-1034

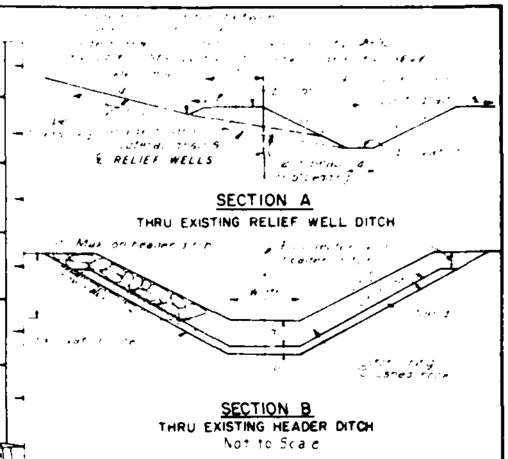
PLATE NO. 21

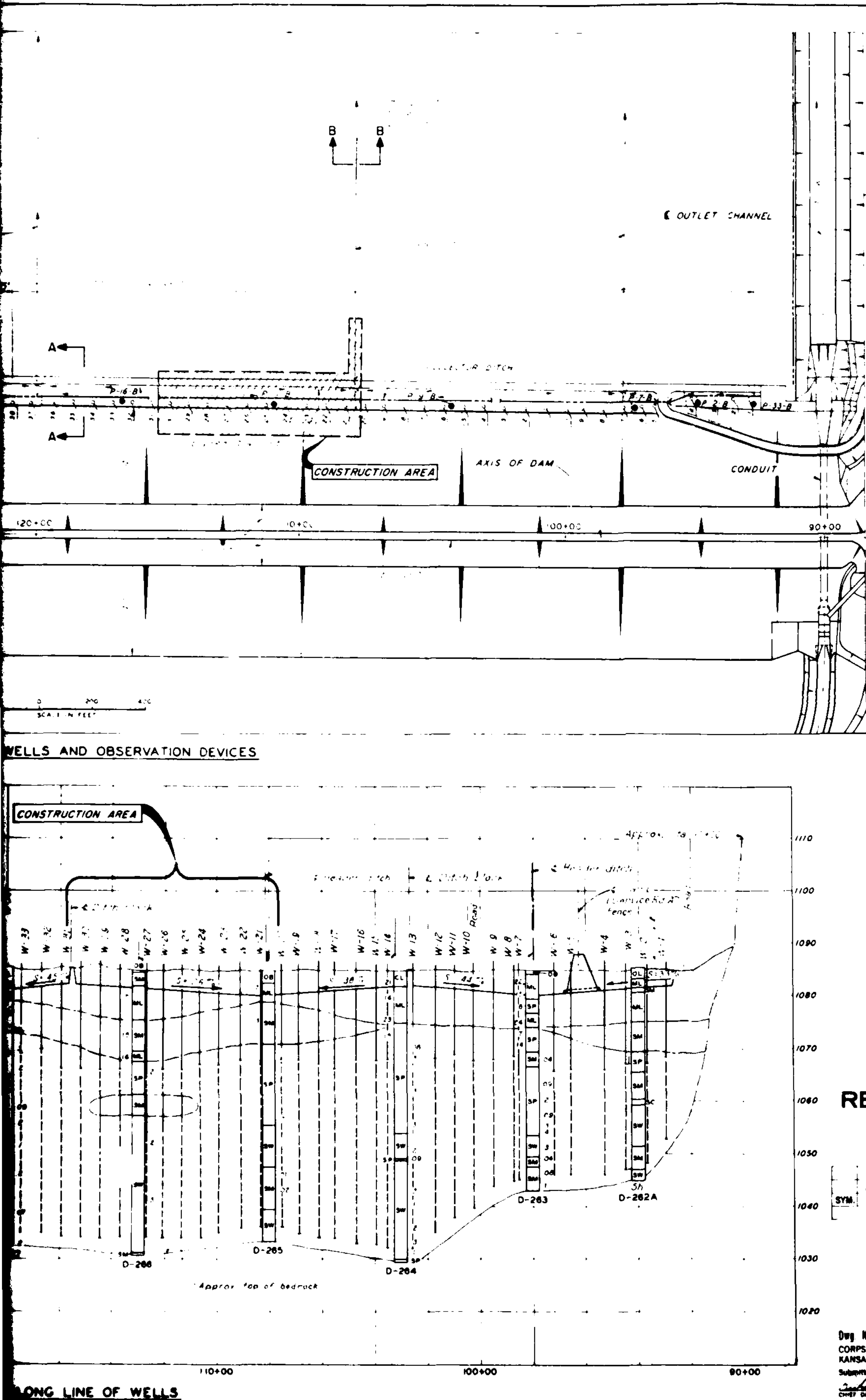


PLAN OF RELIEF WELLS AND OBSERVATION



PROFILE ALONG LINE OF WELLS





RECORD DRAWING

SEPTEMBER 1976

CONTRACT NO. DACW41 76-C-0122

SYM.	DESCRIPTION	DATE	APPD.
	Revised for "As Built" conditions		

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

RELIEF WELL COLLECTOR SYSTEM

EXISTING RELIEF WELLS PLAN AND PROFILE

Dwg No 3

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Scale: as shown
U. S. ARMY
MARCH 1976

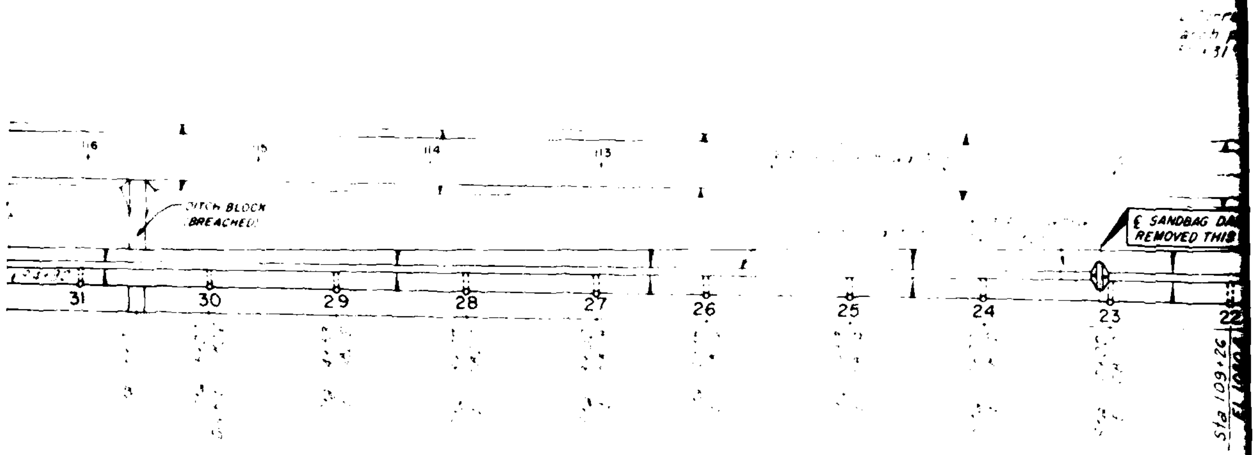
Submitted: CHIEF, DAMS & FOUNDATIONS SECT
Recommended: CHIEF, FOUNDATIONS & MAT'S BR.
Approved: CHIEF, ENGINEERING DIVISION

COMPILED BY: WWB
DRAWN BY: JLE
CHECKED BY: R&D

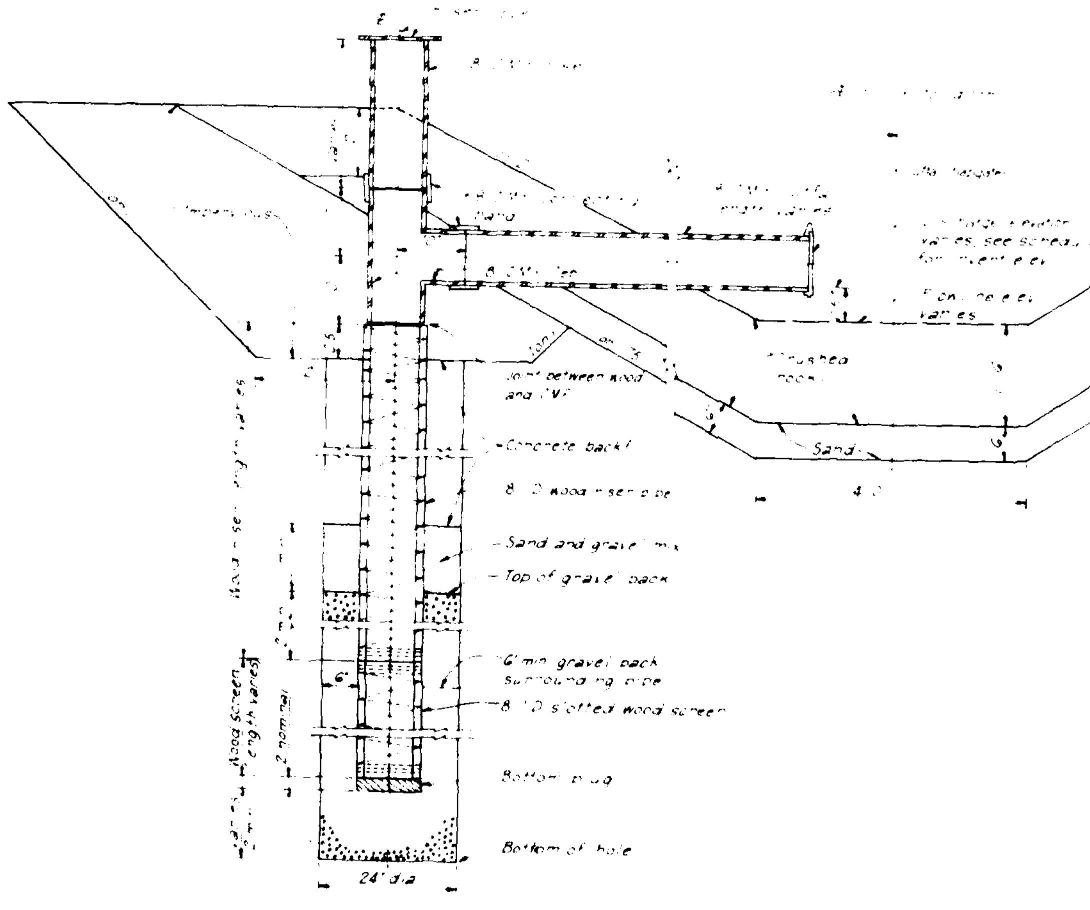
FILE NO. B-1-1873

PLATE NO. 26

2



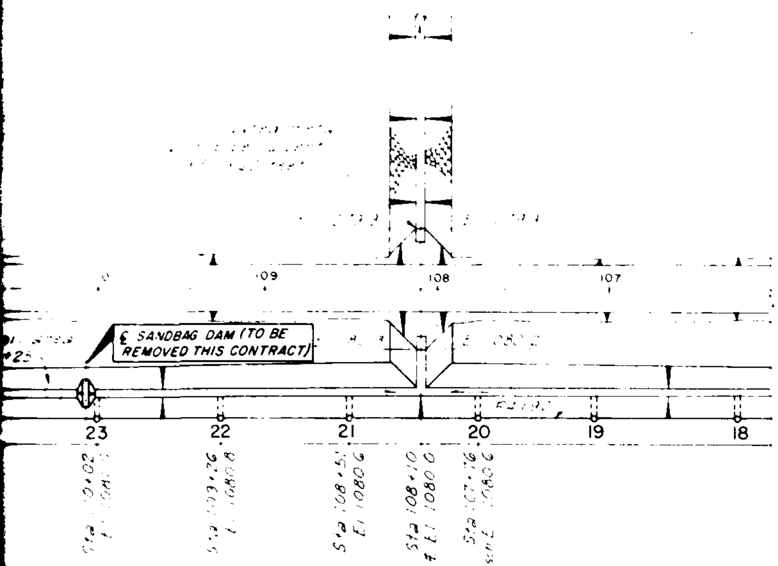
EXISTING RELIEF WELL COLLECTOR SYSTEM



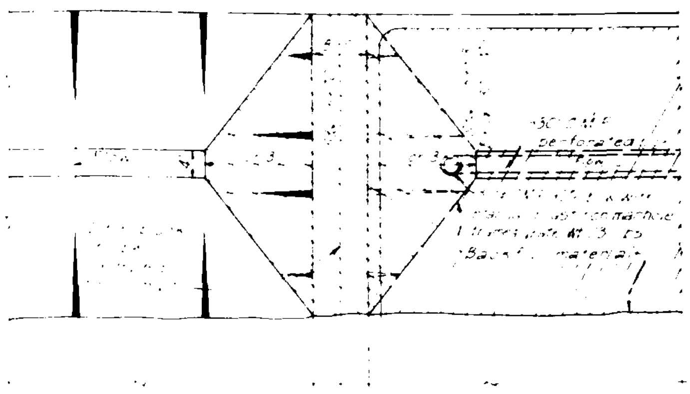
STAFF GAGE READING	DISC… C…
0.20	[illegible]
0.21	[illegible]
0.22	[illegible]
0.23	[illegible]
0.24	[illegible]
0.25	[illegible]
0.26	[illegible]
0.27	[illegible]
0.28	[illegible]
0.29	[illegible]
0.30	[illegible]
0.31	[illegible]
0.32	[illegible]
0.33	[illegible]
0.34	[illegible]
0.35	[illegible]
0.36	[illegible]
0.37	[illegible]
0.38	[illegible]
0.39	[illegible]
0.40	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

DETAIL OF EXISTING RELIEF WELL AND COLLECTOR DITCH

Not to scale

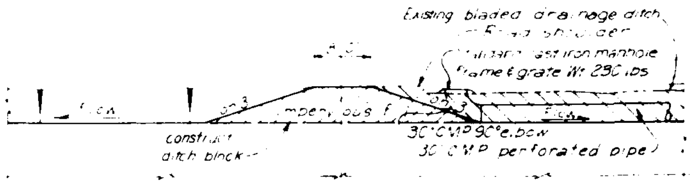


YSTEM



DITCH BLOCK PLAN

Not to scale

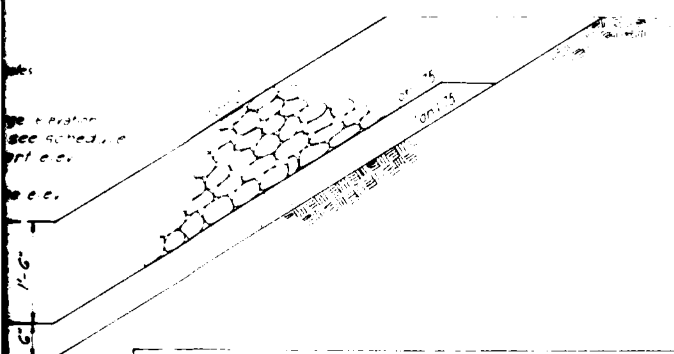


DITCH BLOCK DETAIL

RELIEF WELL COLLECTOR DITCH

Not to scale

Note
Crosshatched area to be constructed this contract



RELIEF WELL SCHEDULE							
WELL NO	LOCATION	CMP OUTFALL PIPE (LIN FT)	DISCHARGE ELEVATION	DISTANCE BETWEEN RELIEF WELLS	CMP RISER (LIN FT)	GPM OCT, 1975	GROUND ELEVS
20	[illegible]	8.0	1080.6	75	4.0	128	1085.0
21	[illegible]	8.0	1080.6	75	4.0	138	1084.9
22	[illegible]	8.0	1080.8	76	4.0	68	1084.9
23	[illegible]	8.0	[illegible]	75	4.0	20	1085.0
24	[illegible]	8.0	1081.2	76	4.0	06	1085.0
25	[illegible]+53	8.0	1081.4	85	4.0	08	1085.1
26	[illegible]+38	6.0	1081.6	64	4.0	4	1085.1
27	3+02	6.0	1081.8	75	4.0	06	1085.1
28	[illegible]	6.0	1082.0	76	4.0	04	1085.1
29	4+53	6.0	1082.2	74	4.0	08	1085.0
30	5+27	6.0	1082.2		4.0	16	1085.0
14 thru 20						1045	

PARSHALL FLUME FREE FLOW DISCHARGE											
STAFF GAGE READING	DISCHARGE CFS	GALLONS GPM	STAFF GAGE READING	DISCHARGE CFS	GALLONS GPM	STAFF GAGE READING	DISCHARGE CFS	GALLONS GPM	STAFF GAGE READING	DISCHARGE CFS	GALLONS GPM
[illegible]	[illegible]	[illegible]	0.43	[illegible]	[illegible]	0.66	4.20	1,885.0	0.89	6.68	2,998.0
[illegible]	[illegible]	[illegible]	0.44	[illegible]	1,005.3	0.67	4.30	1,930.0	0.90	6.80	3,051.8
0.22	0.77	345.6	[illegible]	[illegible]	[illegible]	0.68	4.40	1,974.7	0.91	6.92	3,105.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.69	4.50	2,020.0	0.92	7.03	3,155.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.70	4.60	2,064.5	0.93	7.15	3,208.9
0.25	[illegible]	[illegible]	[illegible]	2.57	[illegible]	[illegible]	4.70	2,109.4	0.94	7.27	3,262.8
0.26	[illegible]	444.3	0.49	2.65	1,189.3	0.72	[illegible]	[illegible]	0.95	7.39	3,316.6
0.27	[illegible]	[illegible]	[illegible]	2.73	[illegible]	0.73	4.91	2,203.6	0.96	7.51	3,370.5
[illegible]	[illegible]	498.0	[illegible]	2.80	1,265.6	0.74	5.02	2,253.0	0.97	7.63	3,424.3
[illegible]	[illegible]	529.6	[illegible]	[illegible]	[illegible]	0.75	[illegible]	2,297.8	0.98	7.75	3,478.2
[illegible]	[illegible]	556.6	0.53	2.99	[illegible]	0.76	5.23	2,347.2	0.99	7.88	3,536.5
[illegible]	[illegible]	[illegible]	[illegible]	3.08	[illegible]	0.77	5.34	2,396.6	1.00	8.00	3,590.4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.78	5.44	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.79	5.55	2,490.8			
[illegible]	[illegible]	[illegible]	0.57	3.35	1,503.5	0.80	5.66	[illegible]			
[illegible]	[illegible]	[illegible]	0.58	[illegible]	1,543.9	[illegible]	5.77	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	3.53	[illegible]	[illegible]	5.88	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.83	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.84	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.85	[illegible]	2,791.5			
[illegible]	[illegible]	[illegible]	0.63	[illegible]	[illegible]	0.86	6.33	2,840.9			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.87	[illegible]	2,890.3			
[illegible]	[illegible]	[illegible]	0.65	[illegible]	[illegible]	0.88	[illegible]	[illegible]			

TOR DITCH

RECORD DRAWING

SEPTEMBER 1976

CONTRACT NO DACW41 76-C-0122

SYM	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions	12/2/82	

REVISIONS

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

RELIEF WELL COLLECTOR SYSTEM

RELIEF WELLS 20 THRU 30
PLAN AND DETAILS

Dwg No 4

CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Scale as shown

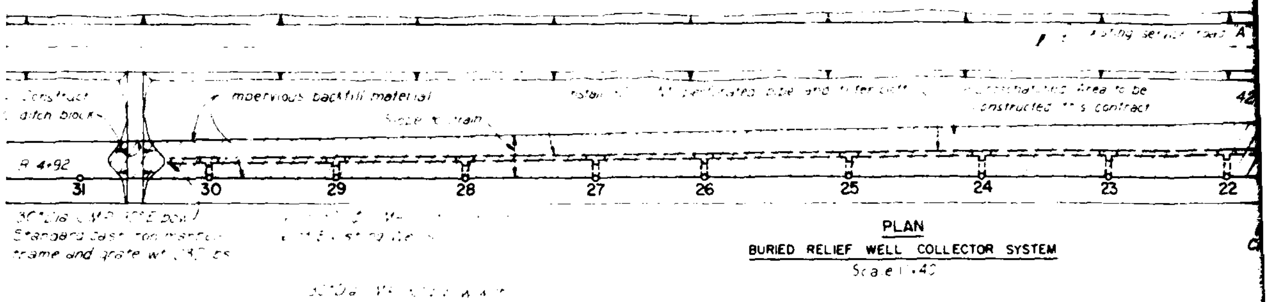
U S ARMY
MARCH 1976

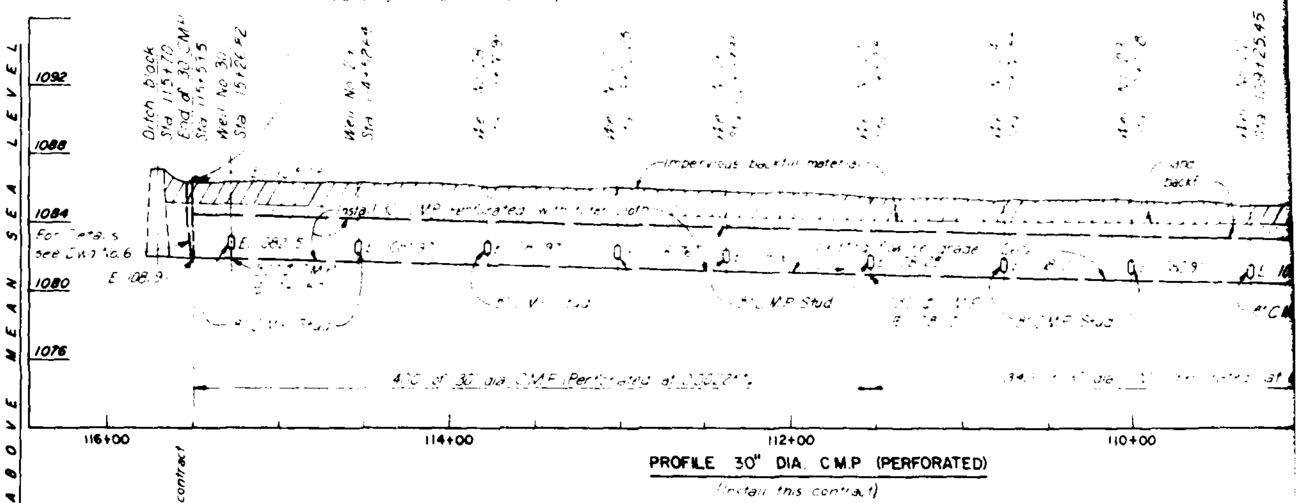
Submitted: CHIEF DAMS & FOUNDATIONS SECT
Recommended: CHIEF FOUNDATIONS & MATLS BR
Approved: CHIEF ENGINEERING DIVISION

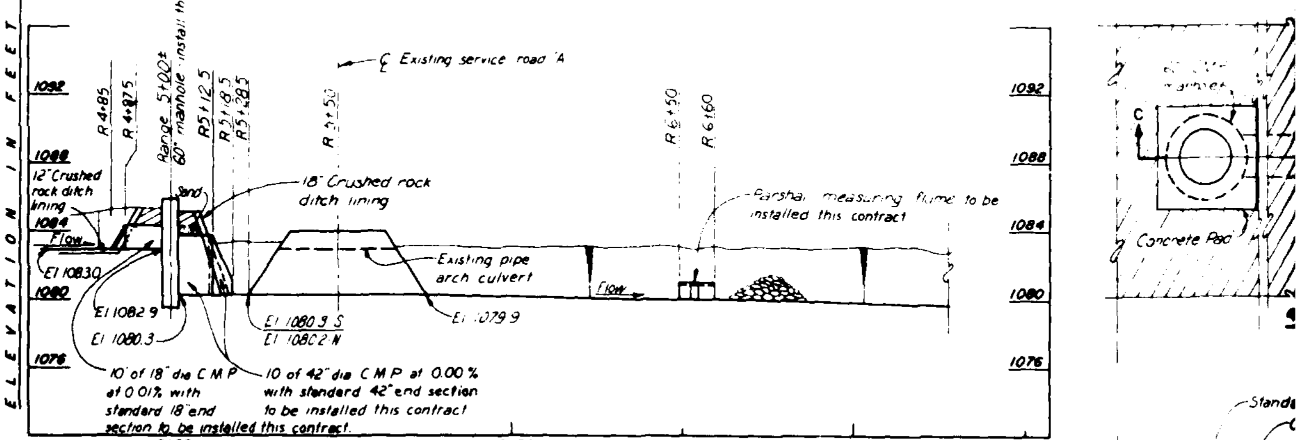
COMPILED BY W W B | DRAWN BY J L E | CHECKED BY R G D

FILE NO B-1-1874

PLATE NO. 27

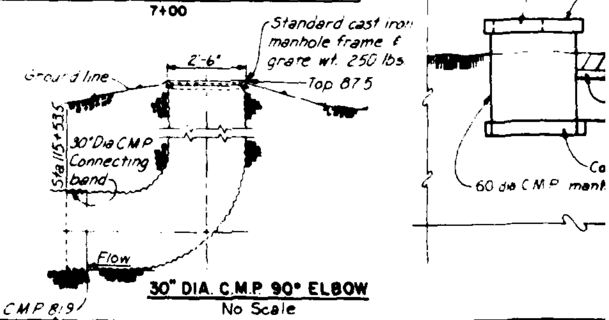




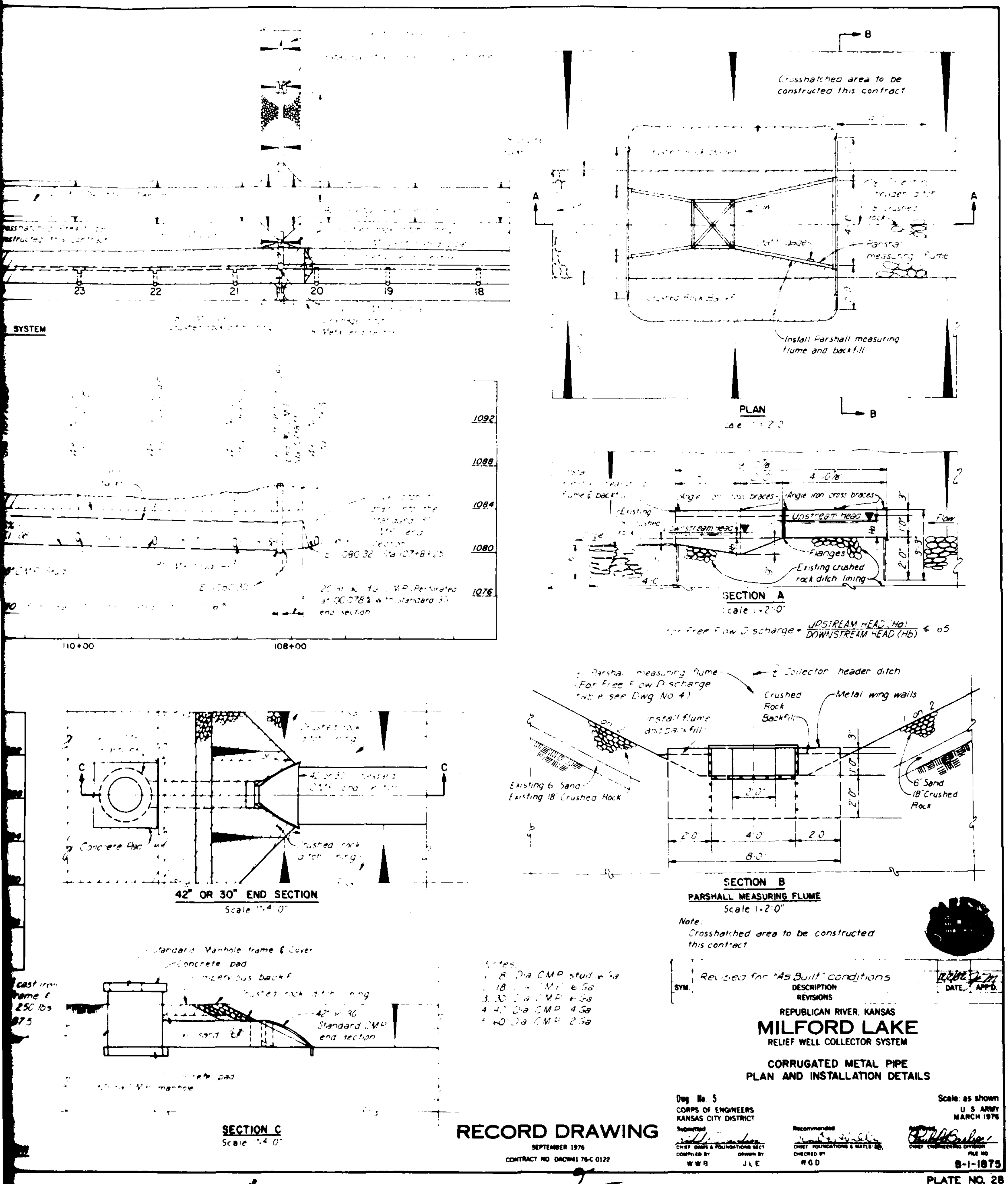


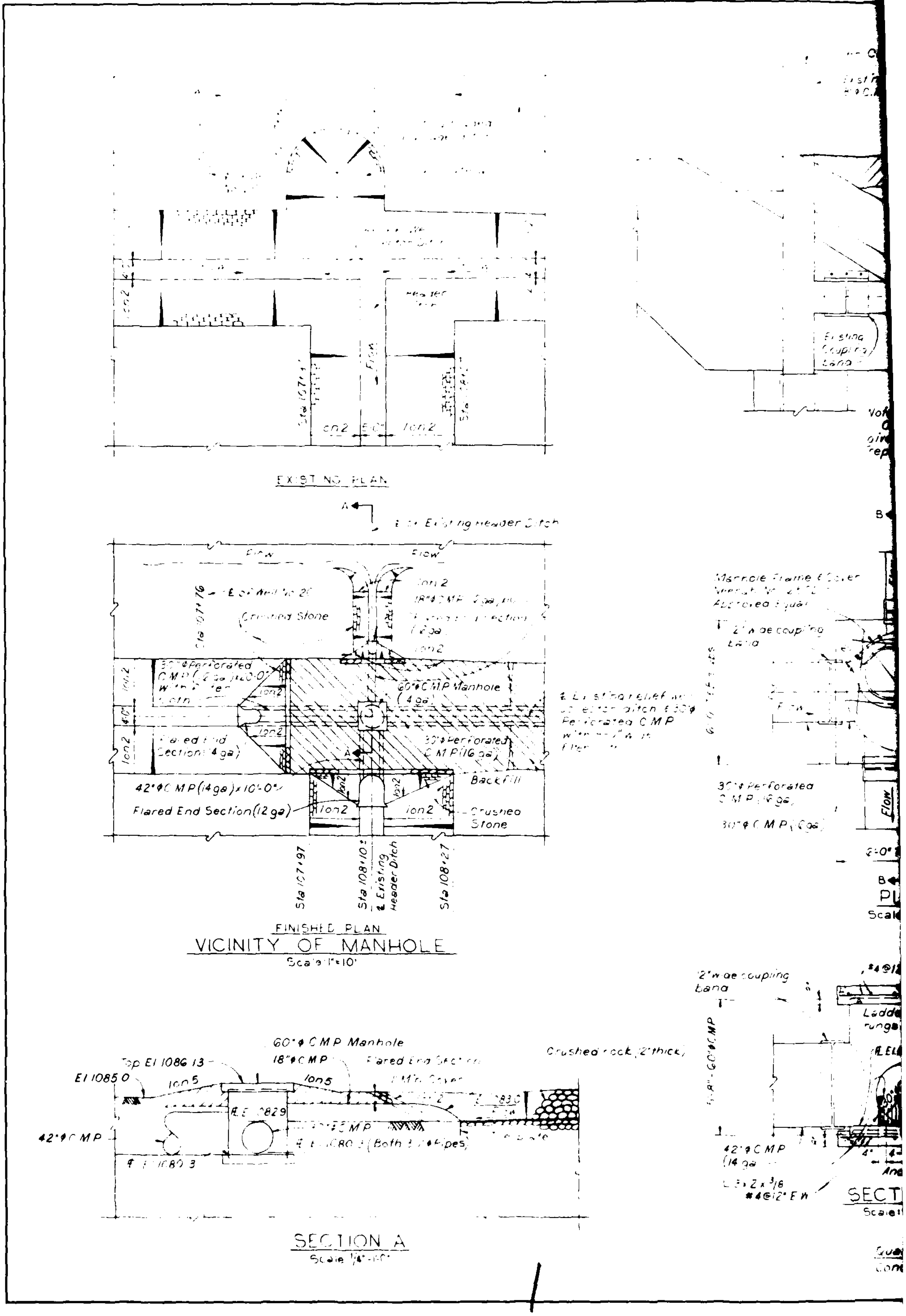
PROFILE 42" DIA. C.M.P.

MATERIALS QUANTITY SCHEDULE	
QUANTITY	ITEM
800 L/FT	8' Wide Poly-Filter-X-Cloth
2 Cu Yds	Reinforce Concrete (Manhole)
50 Cu Yds	Excavation material
1,000 Cu Yds	Impervious backfill
600 Cu Yds	Sand backfill
20 Cu Yds	Crushed rock (Ditch lining)
10 L/FT	18" C.M.P.
760 L/FT	30" C.M.P. (Perforated)
10 L/FT	42" C.M.P.

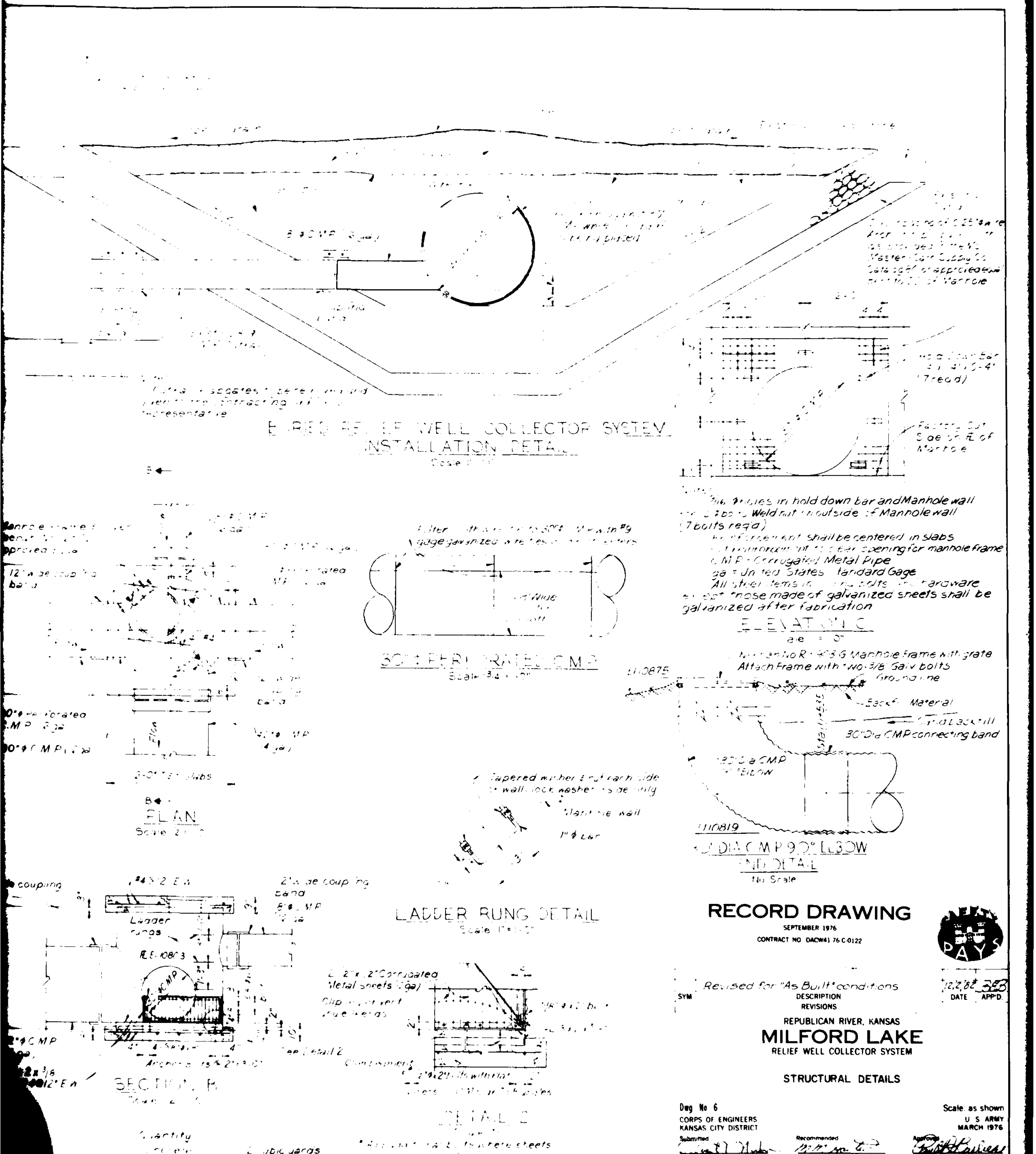


30" DIA. C.M.P. 90° ELBOW
No Scale


SYSTEM
Crosshatched area to be constructed this contract
Install Parshall measuring flume and backfill
PLAN
SECTION A
Scale 1"=2'-0"
Angle iron cross braces
Upstream head
Flow
Flanges
Existing crushed rock ditch lining
For Free Flow Discharge = UPSTREAM HEAD (Ha) / DOWNSTREAM HEAD (Hb) ≤ 65
Collector header ditch
Crushed Rock Backfill
Metal wing walls
Existing 6" Sand
Existing 18" Crushed Rock
6" Sand
18" Crushed Rock
SECTION B
PARSHALL MEASURING FLUME
Scale 1"=2'-0"
Note:
Crosshatched area to be constructed this contract
42" OR 30" END SECTION
Concrete Pad
SECTION C
Revised for "As Built" conditions
DESCRIPTION
REVISIONS
DATE
APPD.
REPUBLICAN RIVER, KANSAS
MILFORD LAKE
RELIEF WELL COLLECTOR SYSTEM
CORRUGATED METAL PIPE
PLAN AND INSTALLATION DETAILS
Dwg No 5
Scale: as shown
CORPS OF ENGINEERS
KANSAS CITY DISTRICT
U S ARMY
MARCH 1976
RECORD DRAWING
SEPTEMBER 1976
CONTRACT NO DACW41 76-C-0122
B-1-1875
PLATE NO. 28



EXISTING PLAN
Flow
Sta 107+91
Sta 108+27
Header Ditch
Existing Header Ditch
Flow
Flow
1 on 2
18" ϕ CMP
Crushed Stone
Sta 107+76
30" ϕ Perforated CMP (12 ga) x 20'-0"
60" ϕ CMP Manhole (14 ga)
Flared End Section (14 ga)
30" ϕ Perforated CMP (16 ga)
42" ϕ CMP (14 ga) x 10'-0"
Flared End Section (12 ga)
Back Fill
Crushed Stone
1 on 2
Sta 107+97
Sta 108+10 ± ℄ Existing Header Ditch
Sta 108+27
FINISHED PLAN
VICINITY OF MANHOLE
Scale 1"=10'
60" ϕ CMP Manhole
18" ϕ CMP
Top El 1086.13
El 1085.0
1 on 5
1 on 5
Flared End Section
Crushed rock (2' thick)
42" ϕ CMP
Both 30" ϕ Pipes
SECTION A
Manhole Frame & Cover
Approved Equal
2" wide coupling band
30" ϕ Perforated CMP (16 ga)
30" ϕ CMP (12 ga)
Flow
Existing Coupling Band
12" wide coupling band
60" ϕ CMP
42" ϕ CMP (14 ga)
L 3 x 2 x 3/16
#4@12" E W



RECORD DRAWING
SEPTEMBER 1976
CONTRACT NO. DACW41-76-C-0122

SYM	DESCRIPTION	DATE	APP'D
	Revised for "As Built" conditions	12/2/82	

REVISIONS

REPUBLICAN RIVER, KANSAS
MILFORD LAKE
RELIEF WELL COLLECTOR SYSTEM

STRUCTURAL DETAILS

Dwg. No. 6
CORPS OF ENGINEERS
KANSAS CITY DISTRICT

Scale: as shown
U. S. ARMY
MARCH 1976

Submitted: CHIEF, GENERAL STRUCTURAL
Recommended: CHIEF, DESIGN BRANCH
Approved: CHIEF, ENGINEERING DIVISION

COMPILED BY RCD | DRAWN BY PWM | CHECKED BY HEF

FILE NO. B-1-1876

PLATE NO. 29

TABLES

MILFORD DA[illegible]

[illegible] ABUTMENT CUTOFF

SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No of Holes	ELEVATION Surface El	ELEVATION Bottom El	EXPLOSIVE COLUMN	Lbs 60 Dyn	Lbs 40 Dyn
[illegible]	[illegible]	Pre Split Back Slope	[illegible]	[illegible]	Air Trac	[illegible]	[illegible]	[illegible]	45°	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	Pre Split Back Slope		Sta [illegible]	Air Trac	[illegible]	[illegible]	[illegible]	45°	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
2	[illegible]	Pre Split Back Slope		Sta [illegible]	Air Trac	[illegible]	[illegible]	[illegible]	45°	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
4	[illegible]	Pre Split Back Slope		Sta [illegible]	Air Trac	[illegible]	[illegible]	[illegible] of Base	45°	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]
5	[illegible]	Pre Split Back Slope		Sta 142+[illegible]	Air Trac	[illegible]	[illegible]	[illegible] of Base	45°	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]
6	9 13 62	Pre Split U Side Slope	[illegible]	Sta 143+00 142+75 [illegible]	Air Trac	[illegible]	[illegible]	[illegible]	45°	[illegible]	14	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	9 14 62	Pre Split U Side Slope		Sta 143+00 142+44 R 0+42 U [illegible]	Air Trac	[illegible]	[illegible]	[illegible]	45°	[illegible]	[illegible]	[illegible]	[illegible]	Same as above		[illegible]
8	9 17 62	Pre Split D Side Slope		Sta 142+68 142+40 R 0+20 D 1+40 D	Air Trac	[illegible]	[illegible]	[illegible]	45°	[illegible]	14	[illegible]		[illegible]		[illegible]
9	9 18 62	Production Blasting		Sta 142+00 to face R ℄ to 0+64 U	Air Trac	[illegible]	[illegible]	7 x 9	Vertical	None	44	[illegible]	[illegible]	A N 4 Stem		[illegible]
10	9 19 62			Sta 142+40 to face R ℄ to 1+20 U	Air Trac	[illegible]	[illegible]	[illegible]	Vertical	None	46	[illegible]		Same as above		[illegible]
[illegible]	9 20 62			Sta 142+40 142+15 R 1+40 D 1+25 U	Air Trac	[illegible]	[illegible]	8 x 11	Vertical	None	[illegible]	1,140		[illegible]		[illegible]
12	9 26 62			Sta 142+75 148+00 R 0+60 U 0+60 D	Air Trac	[illegible]	[illegible]	7 x 8	Vertical	None	36	[illegible]	[illegible]	[illegible]		[illegible]
13	10 10 62	Pre Split U Side Slope		Sta 143+40 143+00 R 1+25 U 0+30 U	Air Trac	3	[illegible]	36 42 C to C	45°	1 on 1	20	1,125		[illegible]		[illegible]
14	10 11 62	Pre Split Back Side Slopes	2nd Lift	Sta 142+00 142+40 R 30 U 1+50 D	Air Trac	3	[illegible]	30 42 C to C	45°	1 on 1	[illegible]	1,125	1,093	[illegible]		[illegible]
15	10 12 62	Production Blasting		Sta 142+00 142+75 R 1+25 U 1+50 D	Air Trac	3	[illegible]	7 x 9	Vertical	None	176	1,125 +		1 S 40% A N 4 Stem	[illegible]	[illegible] 304

MILFORD DAM

OUTLET WORKS

SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No of Holes	ELEVATION Surface El	ELEVATION Bottom El	EXPLOSIVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn
16	10 17 62	Approach Bench		Sta 5+00 U 9+00 U	Air Trac Rotary	3	12	7 x 10	vertical	None	214	1 147 +	1 135	1 S 40% A N 4 Stem	0	260
17	10 18 67	Approach Bench		Sta 6+10 8+71 U	Air Trac Rotary	3½ 4½	16	9 x 12	vertical	None	69	1 151 +		1 S 40% A N 4 Stem	0	[illegible]
18	10 18 62	Pre Split		Sta 6+50 8+79 U	Air Trac	[illegible]	[illegible] 65	42		1 on 0.5	60	1 165 +	1 030 Ramp	S 18 [illegible] Stem	[illegible]	[illegible]
19	10 18 62	Pre Split Approach Bench		Sta 6+50 8+75 U	Air Trac	2	[illegible] 65	42 C to C Line		1 on 0.5	19	1 160 +	1 095 See Remarks	S 28 Upper 2 S 3		
20	10 19 62	Approach Bench Prod Blast	1st Lift	Sta 5+50 9+00 U	Air Trac	2 3	18	9 x 12	Vertical		106	1 155 +	[illegible]	1 S A N 4 Stem		200
21	10 20 62	Approach Bench Prod Blast		Sta 4+20 U 5+50 U	Air Trac	2 3	[illegible]	9 x 12	Vertical		86 59 Pre Split	1 155 +		1 S A N 4 Stem S 18		200
22	10 23 62	R Abut Cutoff Pre Split		℄ Thru U Side Slope	Air Trac	2	28 20	42 C to C Line	45%	1 on 1	47	1 174 +	1 154 +	[illegible] 18		
23	10 24 62	R Abut Cutoff Pre Split		℄ Thru U Side Slope	Air Trac	3	28 20	42 C to C Line	45%	1 on 1	43			S 18		
24	10 24 62	R Abut Cutoff Exposed Slope U		Sta 1+50 3+50 U	Air Trac	3 4	10	7 X 9	Vertica		164		1 164	1 S 60% A N 4 Stem	100	55
25	10 25 62	Exposed Slope U	2nd Lift	Sta 1+50–3+50 U	Air Trac	4 3½	10	9 X 12	vertical	1 on 1	60*	1 164 +	1 154	1 S 60% A N 4 Stem	55	0
26	10 25 62	R Abut Cutoff		℄ Sta 1+50 U	Air Trac	4 3½	10	9 X 12	vertica		63	1 164		1 S 60% A N –4 Stem	30	0
27	10 26 62	R Abut Cutoff		℄ Sta 1+50 U	Air Trac	4½ 3	10	9 X 12	Vertical		68			1S 40% A N –4 Stem	0	80
28	10 27 62	Exposed Slope 1 on 1 D	1st Lift	Sta 1+15 4+70 D	Air Trac	4½ 3½	15	9 X 12 7 X 9	vertical	1 on 1	146	1 168	1 153	1 S 40% A N 4 Stem	[illegible]	[illegible]
29	10 28 62	Exposed Slope 1 on 1 D	2nd Lift	Sta 1+15 4+70 D	Air Trac	4	15	6 X 6	Vertical	1 on 1		1 106	1 091			
30	10 29 62	Approach Bench		Sta 6+50 8+50 U	Air Trac	3	26	7 X 9	Vertica		252	1 137	1 111	1S 60% A N 4 Stem	150	[illegible]

MILFORD DAM

OUTLET WORKS

SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No of Holes	ELEVATION Surface El	ELEVATION Bottom El	EXPLOSIVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn
31	10 30 62	Exposed 1 on 1 Slope Above Stilling Basin and Outlet	1st Lift	Sta 7+00– 8+50 D	Rotary	4	18	9 x 12	Vertical	1 on 1	293	1 173	1 155	1 S 60% A N 4 Stem	150	600
32	11 1 62	R Abut Cutoff & U S 0.5 Slope	2nd Lift	Sta 0+70 3+00 U	Rotary Air Trac	4½ 3½	14	8 x 10	Vertical	1 on 0.5	150	1 154	1 140	1 S 40% A N 4 Stem	0	400
33	11 2 62	Exposed Slope 1 on 1 Above Outlet Channel	1st Lift	Sta 10+00– 10+50 D	Rotary Air Trac	4	18	7 x 9	Vertical	1 on 1	78	1 173	1 155	1 S 40% A N –4 Stem	0	50
34	11 2 62	U S 1 on 5 and Exposed 1 on 1		Sta 2+00– 4+00 U	Air Trac	3½	18	7 x 9	Vertical	1 on 1	78	1 153	1 135	1 S 40% A N –4 Stem	0	50
35	11 3 62	D 1 on 5 and 1 on 1 Service Road Slope		Sta 2+00– 4+00 D	Air Trac	3½	15	7 x 9	Vertical	1 on 1 1 on 0.5						
36	11 4 62	R Abut Cutoff		Sta 0+70– 2+00 D	Air Trac	3½	15	8 X 10	Vertical	None	146	1 154		1 S 60% A N 4 Stem	100	200
37	11 5 62	D 1 on 5	2nd Lift	Sta 2+00 5+00 D	Air Trac	3½	14	8 X 10	Vertical	1 on 1 1 on 0.5	245	1 155		1 S 60% A N 4 Stem	100	1 500
38	11 6 62	Outlet Channel		Sta 5+00 3+00 D	Air Trac	3½	13	8 X 10	Vertical	None	251	1 154		1 S 60% A N –4 Stem	100	400
39	11 7 62	Exposed 1 on 1 Above Outlet Channel		Sta 5+00 9+50 D	Air Trac	3½	15	8 X 10	Vertical	1 on 1	306	1 155	1 140	1 S 60% A N 4 Stem	150	1 500
40	11 8 62	Approach Bench		Sta 5+00– 9+00 U	Air Trac	3½	26	7 x 9	Vertical	None	188	1 137 +	1 111 +	1 S 40% A N 4 Stem	0	100
41	11 10 62	Approach Bench			Air Trac	3½	26	7 x 9	Vertical	None	187			1 S 40% A N 4 Stem	0	300
42	11 11 62	Approach Bench Ramp		Sta 7+00– 9+00 U	Air Trac	3	20	7 x 9	Vertical	Ramp Grade 1 on 0.5	15			1 S 40% A N 4 Stem	0	[illegible]
43	11 11 62	R Abut Cutoff Pre Split Delay	3rd Lift	Sta 1+00– 1+00 D	Air Trac Rotary	3½ 4½	38 12	42 C to C 7 x 9	45° Vertical	1 on 1 None	160	1 158	1 140	S 15 4 Stem 1 S 40% A N 4 Stem	0	150
44	11 12 62	Approach Bench		Sta 5+50– 6+00 U	Air Trac	3½	26	7 x 9	Vertical	None	129		1 111 +	S 15 4 Stem 1 S 40% A N 4 Stem	0	150
45	11 13 62	Approach Bench	2nd Lift	Sta 5+00 –5+50 U	Air Trac	3	26	7 x 9	Vertical	None	105	1 137 +		S 15 4 Stem 1 S 40% A N 4 Stem	0	52

MILFORD DAM BLASTING RECORD TABLE 1

EXPLOSIVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn	Lbs A N	Total Explos	Est Yd Rock	Lbs Yd	CAPS 1	DELAYS 1	2	3	4	5	PRIMA CORD	RESULTS	METHOD OF EXCAV	UTILIZATION	GEOLOGIC F M	REMARKS
1 S [illegible]	[illegible]												[illegible]	[illegible]			[illegible]	[illegible]
1S [illegible]	[illegible]		[illegible]										[illegible]	[illegible]			[illegible]	[illegible]
1/2 S [illegible]													[illegible]	[illegible]			[illegible]	[illegible]
Sa[illegible]	[illegible]		[illegible]										[illegible]	[illegible]			[illegible]	Adjacent shot made loading [illegible] middle holes
Sa[illegible]	[illegible]		[illegible]										[illegible]	[illegible]			[illegible]	
S[illegible] Ste[illegible]	[illegible]												[illegible]	[illegible]			[illegible]	
Sa[illegible]	[illegible]		[illegible]										[illegible]	[illegible]			[illegible]	
Co[illegible]	[illegible]		[illegible]										[illegible]	[illegible]			[illegible]	This shot completes [illegible]
1S [illegible] A N 4 [illegible]		[illegible]	[illegible]	[illegible]			[illegible]						[illegible]	[illegible]	[illegible] Northwest [illegible]	U S Sh and Ls Blanket	[illegible]	Oversize due to [illegible] rock capping [illegible] with [illegible]
Same [illegible]		[illegible]	[illegible]	[illegible]			[illegible]						[illegible]	[illegible]	[illegible] Northwest [illegible]	U S Sh and Blanket	[illegible]	
S[illegible] Stem [illegible]	[illegible]		[illegible]	[illegible]			NR	NR	NR	NR	NR	NR	[illegible]			U S Sh and Ls Blanket	[illegible]	
S[illegible] Stem [illegible]	[illegible]		[illegible]	[illegible]			NR	NR	NR	NR	NR	NR	[illegible]	[illegible]	[illegible] Northwest [illegible]	U S Sh and Ls Blanket	[illegible] Riley B C D E OKETO	This shot completes [illegible]
[illegible]	[illegible]		[illegible]										[illegible]	[illegible]	[illegible]		Florence A B C D	
[illegible]	[illegible]		[illegible]										[illegible]	[illegible]			Florence A B C D	
1 S 40% A N 4 Stem	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	Shot kicked out bottom [illegible] Poor breakage oversize	[illegible] Northwest [illegible] unable to excavate due to poor breakage	U S Sh and Ls Blanket [illegible]	Florence A B C D	Approx [illegible] of this material was excavated and the operation abandoned and contractor added [illegible] later shot

MILFORD DAM BLASTING RECORD - TABLE 2

EXPLOSIVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn	Lbs A N	Total Explos	Est Yd Rock	Lbs Yd	CAPS 1	DELAYS 1	2	3	4	5	PRIMA CORD	RESULTS	METHOD OF EXCAV	UTILIZATION	GEOLOGIC F M	REMARKS
1 S 40% A N 4 Stem		200	[illegible]	[illegible]	[illegible]	[illegible]	4[illegible]	4[illegible]	4[illegible]	4[illegible]	48	[illegible]	No	Size Gradation Good	Marion Shovel	U S Sh and Ls Blanket	Fort Riley D E	
1 S 40% A N 4 Stem			[illegible]	[illegible]	[illegible]	[illegible]	NR	NR	NR	NR	NR	NR	No	Size Gradation Good	Marion Shovel	U S Sh and Ls Blanket	Fort Riley C D	
[illegible]S 28 [illegible] Stem													Yes	Good Fracture			Fort Riley B C D E OKETO Florence A B C	
1/28 Upper 1S [illegible]													Yes	Good Fracture	Marion Shovel		Fort Riley B C D E OKETO Florence A B C	Ramp elev varies from 1 095 to [illegible]
U/S A N 4 Stem		200	5 500	[illegible]	[illegible]								See Remarks	Gradation Good	Marion Shovel	Sh and Ls Blanket	Fort Riley B C D E Pre Split Thru Florence	[illegible] pre split holes tied to this shot primacord
1 S A N 4' Stem [illegible] 28		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	NR	NR	NR	NR	NR	NR	Yes Pre split Holes [illegible]	Good Fracture	Marion Shovel	Sh and Ls Blanket	Fort Riley B C D E Pre Split Thru Florence	1st major pre split delay shot
[illegible] 28													Yes	Good Fracture			Fort Riley A B C	Contractor desired to shoot this as a delay production blasting request denied
S 28													Yes	Good Fracture			Fort Riley A B C	Contractor desired to shoot this as a delay production blasting request denied
1 S 60% A N 4 Stem	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	No	Size Gradation Good	Marion Shovel	Sh and Ls Blanket	Fort Riley A	
1 S 60% A N 4 Stem	55	[illegible]	[illegible] 800	[illegible]	2 400		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	No	Overshot Back Break into slope	Marion Shovel	Sh and Ls Blanket	Fort Riley A	
1 S 60% A N 4 Stem	30	[illegible]	4 [illegible]	4 [illegible]50	4 536	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	No	Size Gradation Good	Marion Shovel	Sh and Ls Blanket	Fort Riley A B C	
1S 40% A N 4 Stem	0	90	5 [illegible]	[illegible]	[illegible]	[illegible]	2[illegible]	2[illegible]	34	39	45	0	No	Size Gradation Good	Marion Shovel	Sh and Ls Blanket	Fort Riley A B C	
1 S 40% A N 4 Stem	[illegible]	[illegible]70	[illegible]	[illegible]	[illegible]		30	29	29	29	29	[illegible]	No	Oversize Back Break	Marion Shovel	Sh and Ls Blanket	Fort Riley A B C	Middle of shot excess fines water poor breakage
							NR	NR	NR	NR	NR	NR	No	Overshot Fine	Marion Shovel	Sh and Ls Blanket	Florence C D	Shot damaged drilling left at top of cut
1S 60% A N 4 Stem	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	NR	NR	NR	NR	NR	NR	No	Size Gradation Good	Marion Shovel	Sh and Ls Blanket	OKETO Florence A B C	

MILFORD DAM BLASTING RECORD - TABLE 3

EXPLOSIVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn	Lbs A N	Total Explos	Est Yd Rock	Lbs Yd	CAPS 1	DELAYS 1	2	3	4	5	PRIMA CORD	RESULTS	METHOD OF EXCAV	UTILIZATION	GEOLOGIC F M	REMARKS
1S 60% A N 4 Stem	150	600	9 400	10 150	21 [illegible]	5	174	28	28	30	33	0	No	Gradation Size OK	Marion Shovel	Sh and Ls Blanket	F R B C	
1S 40% A N 4 Stem	0	400	5 [illegible]	[illegible]	[illegible]	4	NR	NR	NR	NR	NR	NR	No	Good Size Gradation	Marion Shovel	"	F R C D	
1S 40% A N 4 Stem	0	50	2 500	2 550	3 256	8	NR	NR	NR	NR	NR	NR	Yes	Oversize	Marion Shovel		F R B C	Primacord and 40% Dyn primer was used due to adjacent powerline
1S 40% A N 4 Stem	0	50	2 500	2 550	3 260	78	NR	NR	NR	NR	NR	NR	Yes	Size Gradation Good Slope Fair	Marion Shovel	U S Sh and Ls Blanket	F R B C	Primacord and 40% Dyn primer was was used due to adjacent powerline
															Marion Shovel	U S Sh and Ls Blanket	F R B C	
1S 60% A N -4 Stem	100	200	3 [illegible]	3 400	6 424	52	55	24	24	24	24	0	No	Size Gradation Good	Marion Shovel	U S Sh and Ls Blanket	F R C D	
1S 60% A N -4 Stem	100	2 500	3 000	5 500	10 045	5[illegible]	NR	NR	NR	NR	NR	NR	No	Some Oversize	Marion Shovel	U S Sh and Ls Blanket	F R C D	
1S 60% A N -4 Stem	100	400	[illegible]	[illegible] 900	4 780	60	NR	NR	NR	NR	NR	NR	No	Same Oversize	Marion Shovel	U S Sh and Ls Blanket	F R C D	
1S 60% A N -4 Stem	150	1 500	4 000	5 650	13 464	40	100	50	50	50	56	0	No	Gradation and Size Good	Marion Shovel	U S Sh and Ls Blanket	F R C D	
1S 40% A N -4 Stem	0	100	14 100	14 200	11 280	1 28	NR	NR	NR	NR	NR	NR	No	Gradation and Size Good	Marion Shovel	Sh and Ls Fill Embankment	Florence A B F R E OKETO	
1S 40% A N -4 Stem	0	300	13 400	13 700	11 220	1 2[illegible]	50	34	34	34	34	[illegible]	No	Gradation and Size Good	Marion Shovel	Sh and Ls Fill Embankment	Florence A B F R E OKETO	
1S 40% A N 4 Stem	[illegible]	[illegible]	600	6[illegible]5	690	98	3	4	4	4	[illegible]	0	No		D 9	Sh and Ls Fill Embankment	Florence A B F R E OKETO	
[illegible] - 4 Stem 1 S A N 4 Stem	0	150	1 000	3 150	4 480	71	30	32	32	32	32	0	Yes See Remarks	Good Gradation Size Slope Results Good	Marion Shovel	Sh and Ls Fill Embankment	Florence A B Florence A	Pre split delay shot slope some minor backbreak along joints in upper 12 0 Lower results good
[illegible] - 4 Stem 1 S A N 4 Stem	0	150	9 600	9 750	9 000	1 0	30	30	30	30	30	0	No	Good Size and Gradation	Marion Shovel	Sh and Ls Fill Embankment	Florence A B	
[illegible] 4 Stem 1 S A N 4 Stem	0	52	1 440	1 492	6 300	1 18	21	21	21	19	17	27	No	Good Size and Gradation	Marion Shovel	Sh and Ls Fill Embankment	Florence A B	

REPUBLICAN RIVER KANSAS

MILFORD LAKE

FOUNDATION REPORT

BLASTING RECORD
TABLES 1, 2 AND 3

[illegible] sheet Sheet No 1 Not to scale

CORPS OF ENGINEERS U S ARMY
KANSAS CITY DISTRICT

FILE NO. B-1-1950

APRIL 197[illegible]

2

TABLES 1,2 & 3

MILFORD DAM

	SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole D	Depth	DRILLING Pattern	Angle	Slope	No. of Holes	ELEVATION Surface El	ELEVATION Bottom El	EXPLOSIVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn	Lbs.
	46	11-13-62	Approach Bench	2nd Lift	Sta 4+50—5+00 U	Air Trac	3½	26	8 X 10	Vertical	None	86	1 137 ±		1 S 60% A N 4 Stem	50	0	[illegible]
	47	11-14-62	Approach Area		Sta 4+00—4+50 U	Air Trac	3½	24	8 X 10	Vertical	1 on 1 1 on 0.5	93			1 S 60% A N 4 Stem		50	[illegible]
	48	11-15-62	Tower Area		Sta 2+00—4+00 U	Air Trac	3½	24	8 X 10	Vertical	1 on 0.5							
	49	11-16-62	R Abut Cutoff		Sta 2+00 U ℄	Air Trac	3½	26	8 X 10	Vertical	None		1 135 ±	1 111 ±				
	50	11-18-62	R Abut Cutoff		℄ Sta 2+50 D	Air Trac	3½	26	8 X 10	Vertical	None	208			1 S 40% A N 4 Stem		104	[illegible]
OUTLET WORKS	51	11-19-62	1 on 0.5		Sta 2+50—5+00 D	Air Trac	3½	26	8 X 10	Vertical	1 on 0.5	179	1 140 ±	1 114 ±	1 S 40% A N 4 Stem		90	[illegible]
	52	11-20-62	Slope Above		Sta 2+50—6+00 D	Air Trac	3½	26	7 X 9	Vertical	1 on 1	208	1 142 ±	1 116 ±	1 S 40% A N 4 Stem	0	104	[illegible]
	53	11-21-62	Stilling Basin	3rd Lift	Sta 4+00—7+50 D	Air Trac	3½	26	7 X 9	Vertical	1 on 1	240			1 S 40% A N - 4 Stem	0	120	[illegible]
	54	11-23-62	and Outlet		Sta 5+00—7+50 D	Air Trac	3½	26	7 X 9	Vertical	1 on 1	266	1 143 ±	1 117 ±	1 S 40% A N - 4 Stem	0	133	[illegible]
	55	11-24-62	Channel		Sta 7+50—10+50 D	Air Trac	3½	26	7 X 9	Vertical	1 on 1	90			1 S 40% A N 4 Stem	0	40	[illegible]
	56	11-25-62	Approach Bench		Sta 7+50—8+50 U	Air Trac Rotary	3½ 4½	16	8 X 10 9 X 12	Vertical	None	109	1 111 ±	1 095 ±	1 S 40% A N 4 Stem	0	54	[illegible]
	57	11-25-62			Sta 6+50—7+50 U	Air Trac	3½	16	8 X 10	Vertical	None	281			1 S 40% - A N -4 Stem	0	150	[illegible]
	58	11-26-62	Final Grade		Sta 5+00—6+50 U	Air Trac	3½	16	9 X 12	Vertical	None	299			1 S 40% - A N - 4 Stem	0	425	[illegible]
	59	11-28-62	Tower	4th Lift	Sta 5+00—2+50 U	Air Trac	3½	16	9 X 12	Vertical	1 on 0.5	316			1 S 40% - A N 4 Stem	0	500	[illegible]
	60 61	11-28-62	R Abut Cutoff Pre-Split		Cutoff Slope	Air Trac	3½	16	42 C to C	45°	1 on 1	67	1 114 ±	1 098 ±	¼ S 18 4 Stem	0	100	0

MILFORD DAM BL

	SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No. of Holes	ELEVATION Surface El	ELEVATION Bottom El	EXPLOSIVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn	Lbs. A
	62	11-29-62	Cutoff		Sta 2+50 U—2+50 D	Air Trac	3½	16	9 X 12	Vertical	None	399	1 114 ±	2+50 D	1 Stick 40% - A N - 4 Stem	0	800	[illegible]
	63	11-30-62	1 on 0.5—1 on 1 Above Stilling Basin		Sta 2+50 D—5+25 D	Air Trac	3½	16	9 X 12	Vertical	1 on 0.5 1 on 1	293	1 116	4+00 D 1 100	1 Stick 40% - A N -4 Stem	0	950	[illegible]
	64	12-4-62	1 on 1 Above Outlet	4th Lift	Sta 5+25—7+50 U	Air Trac	3½	24	9 X 12	Vertical	1 on 1	254	1 117	1 093 Final	1 Stick 40% - A N -4 Stem	0	600	[illegible]
OUTLET WORKS	65	12-4-62	Approach Channel		Sta 7+00—10+00 U	Air Trac	3½	24	9 X 12	Vertical	1 on 1	286	10+50 D	For Bench 10+50 D	1 Stick 40% - A N -4 Stem	0	300	[illegible]
	66	12-5-62			Sta 4+50 U—6+00 U	Air Trac Rotary	3½ 4½	12	7 X 9 10 X 14	Vertical	1 on 1.5	157	1 095 ±	8+00 U	1 Stick 40% A N -4 Stem	0	300	[illegible]
	67	12-6-62	Final Grade		Sta 6+00—5+00 U	Air Trac Rotary	3½ 4½	16	9 X 12 10 X 14	Vertical	1 on 1.5	170	1 096		1 Stick 40% A N - 4 Stem	0	300	[illegible]
	68	12-13-62	Right Abutment Pre-Split		Cutoff Slopes	Air Trac	3½	17 (24)	48 C to C	45°	1 on 1	57	1.097	1 080	¼ Stick 40% 18	0	200	[illegible]
	69	12-14-62	Approach Wall		Sta 3+00 U	Rotary	4½	13	10 X 14	Vertical	1 on 0.5	137	1.096		1 Stick 60% - A N 4 Stem	250	0	[illegible]
	70	12-15-62	Conduit Outside Slope	5th Lift	Sta 3+00 U ℄	Air Trac Rotary	3½ 4½	17	10 X 14	Vertical	1 on 0.5 1 on 1	123	1.097	250 D	1 Stick 60% - A N -4 Stem	100	300	[illegible]
	71	12-16-62			Sta 2+50 D ℄	Air Trac Rotary	3½	17	10 X 14	Vertical	1 on 0.5 1 on 1	87	1.097		1 Stick 65% - A N - 4 Stem	100	1 250	[illegible]
SERVICE ROAD	72	12-13-62		1st Lift	Sta 11+50	Air Trac Rotary	3½ 4½	18	9 X 12	Vertical	1 on 1	236	1.163 ±	1.150	1 Stick 40% - A N -4 Stem	0	1 160	[illegible]
	73	12-13-62	Service Road "A" Final	2nd Lift	Sta 20+00 D	Air Trac Rotary	3½ 4½	22	9 X 12	Vertical	1 on 1	150	1.150	1 128	1 Stick 40% - A N -4 Stem	0	300	[illegible]
	74	12-20-62		5th Lift	Sta 17+00—20+00	Air Trac Rotary	3½ 4½	20	9 X 12	Vertical	1 on 1	175	9+00 D	Final Grade 5+00 D	1 Stick 40% - A N -4 Stem	0	1 350	[illegible]
	75	12-20-62	1 on 1.5 Slope		Sta 7+00 D—8+00 D	Air Trac Rotary	3½ 4½	10	10 X 12	Vertical	1 on 1.5	126	1 093	1 073	1 Stick 40% - A N -4 Stem	0	200	[illegible]

MILFORD DAM BLA

	SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No. of Holes	ELEVATION Surface El	ELEVATION Bottom El	EXPLOSIVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn	Lbs. A
	76	12-27-62	1 on 1.5 Slope		Sta 7+00—5+00 D	Air Trac Rotary	3½ 4½	20	9 X 12	Vertical	1 on 1.5	80	1 093	1 073	1 S 40% A N -4 Stem	0	400	[illegible]
	77	12-28-62	Stilling Basin Outlet		Sta 5+00—4+00 D	Air Trac Rotary	3½ 4½	20	9 X 12	Vertical	1 on 1.5	91			1 S 40% A N -4 Stem	0	600	[illegible]
	78	12-29-62	Tower Key		Sta 2+50—4+00 D	Air Trac Rotary	3½ 4½	20	9 X 12	Vertical	None	82	1 100	1 080	1 S 40% A N 4 Stem	0	800	[illegible]
	79	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	80	2-20-63	Tower Key		Sta 3+46—3+76 D	Air Trac Rotary	3½ 4½	5.0	5 X 5	Vertical	Vertical	57	1 079	1 072	4 S Dyn 2 Stem	0	125	[illegible]
OUTLET WORKS	81	4-11-63	Discharge Channel		Sta 7+25—8+10 D	Rotary	4½	12	4 X 8	Vertical	1 on 1.5	123			1 S 40% A N -4 Stem	0	100	[illegible]
	82	4-12-63	Discharge Channel		Sta 6+65—7+50 D	Rotary	4½	12	8 X 10	Vertical	1 on 1.5	80	1 082 ±	1 070 ±	1 S 40% or 60% A N -4 Stem	500	250	[illegible]
	83	4-12-63	Discharge Channel	5th Lift	Sta 6+65—7+25 D	Rotary	4½	12	8 X 12	Vertical		38			1 S 80% A N -4 Stem	50	0	[illegible]
	84	4-13-63	Discharge Channel		Sta 6+65—7+25 D	Rotary	4½	12	10 X 15	Vertical	1 on 1.5	48			1 S 40% or 60% A N -4 Stem	1 000	100	[illegible]
	85	—	Stilling Basin		Sta 6+02—4+50 D	Rotary	4½	11	6 X 8	Vertical	1 on 0.5	100			8 Sticks - 6 Stem	300	100	[illegible]
	86	—	Stilling Basin		Sta 6+02—4+50 D	Rotary	4½	10	6 X 8	Vertical	1 on 0.5	175	1 067 ±	1 057 ±	24 Sticks - 40% - 6 Stem	0	2 200	[illegible]
	87	—	Stilling Basin		Sta 6+02—7+27 D	Rotary	4½	10	6 X 9	Vertical	1 on 0.5	153			Same as above	1 400	300	[illegible]
	88	4-17-63	Stilling Basin		Sta 6+02—7+27 D	Rotary	4½	10	6 X 10	Vertical	1 on 0.5	53			Same as above	500	100	[illegible]
	89	4-18-63	Stilling Basin		Sta 4+70—6+02 D	Rotary	4½	10	6 X 10	Vertical	1 on 0.5	63	1 057 ±	1 045 ±	Same as above	800	100	[illegible]
	90	4-19-63	Stilling Basin		Sta 4+00—4+73 D	Rotary	4½	10	6 X 10	Vertical	1 on 0.5	55			Same as above	0	45% - 2 500	[illegible]

MILFORD DAM BLASTING RECORD — TABLE 4

LOSIVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn	Lbs A N	Total Explos	Est Yd Rock	Lbs Yd	CAPS DELAYS I	1	2	3	4	5	PRIMA CORD	RESULTS	METHOD OF EXCAV	UTILIZATION	GEOLOGIC F M	REMARKS
1 S 60% AN 4 Stem	50		4 700	4 750	5 160	91		15	18	21	26	0	No	Good Size and Gradation	Marion Shovel	Sh and Ls F Embankment	Florence A B	
1 S 60% AN 4 Stem		50	5 450	5 500	6 686	82							No	Good Size and Gradation	Marion Shovel	Sh and Ls F Embankment	Florence A B	
													No		Marion Shovel	Sh and Ls F Embankment	Florence A B	
														Breakage Poor Oversize	Marion Shovel	Sh and Ls F Embankment	Florence A B	Approx . of this shot misfired very wet surface conditions
1 S 40% AN 4 Stem		104	11 300	11 404	16 016	55	35	85	0	31	44	0	No	Good	Marion Shovel	Sh and Ls F Embankment	Florence A B	
1 S 40% AN 4 Stem		90	10 900	11 000	13 783	61	55	27	25	31	41	0	No	Good	Marion Shovel	Sh and Ls F Embankment	Florence A B	
1 S 40% AN 4 Stem	0	104	11 300	11 404	12 400	90	100	21	21	23	43	0	No		Marion Shovel	Fill	Ft Riley OKETO Florence A B	
1/S 40% AN 4 Stem	0	120	13 900	14 020	14 400	1 0	125	25	25	25	40	0	No		Marion Shovel	Fill	Ft Riley OKETO Florence A B	
1/S 40% AN 4 Stem	0	133	16 250	16 383	15 960	1 0	150	25	30	30	31	0	No		Marion Shovel	Fill	Ft Riley OKETO Florence A B	Shot broke adjacent powerline
1/S 40% AN —4 Stem	0	40	3 750	3 790	5 400	70	18	11	15	20	25	0	No		Marion Shovel	Fill	Ft Riley OKETO Florence A B	
1/S 40% AN —4 Stem	0	54	5 000	5 054	5 450	90	29	20	17	26	17	0	No		Marion Shovel	Fill	Florence Ls C D	
1 S 40% AN —4 Stem	0	150	11 600	11 750	13 207	87	108	43	44	45	45	0	No		Marion Shovel	Fill	Florence Ls C D	
1/S 40% AN —4 Stem	0	425	11 350	11 900	19 136	62	104	36	50	46	62	0	No		Marion Shovel	Fill	Florence Ls C D	
1/S 40% AN —4 Stem	0	500	11 600	14 225	20 224	70	94	59	38	47	78	0	No		Marion Shovel	Fill	Florence Ls C D	
½S 18 4 Stem	0	300	0	300			2	0	0	0	0	0	Yes		Marion Shovel	Fill	Florence Ls C D	

MILFORD DAM BLASTING RECORD — TABLE 5

IVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn	Lbs A N	Total Explos	Est Yd Rock	Lbs Yd	CAPS – DELAYS 0	1	2	3	4	5	PRIMA CORD	RESULTS	METHOD OF EXCAV	UTILIZATION	GEOLOGIC F M	REMARKS
Stick 40% — N —4 Stem	0	800	1 065 D T 13 200	15 065	25 536	62	132	52	45	45	65	0	No			Fill		
Stick 40% — N —4 Stem	0	950	1 285 D T 8 400	10 635	26 956	47	108	48	47	40	50	0	No		Marion Shovel		Florence Limestone C D	
Stick 40% — N —4 Stem	0	600	655 D T 6 900	8 155	25 368	36	112	38	42	32	40	0	No					
Stick 40% — N —4 Stem	0	300	115 D T 14 900	15 315	26 312	57	124	29	34	38	61	0	No			Shale and Limestone Blanket II	Blue Springs Shale A	
Stick 40% N —4 Stem	0	300	250 D T 6 350	6 900	6 508	1 0	37	35	23	62	0	0	No					
Stick 40% N —4 Stem	0	300	740 6 850	7 890	11 730 22 706	65	25	27	33	32	50	0	No					
Stick 40% 18	0	200	0	200			1	0	0	0	0	0	Yes					
Stick 60% — N —4 Stem	250	0	250 6 000	6 500	9 284		NR	NR	NR	NR	NR	NR	No					Contractor required to stem bottom of holes 3 as drilling depth for this area encroached on drilling limits beginning bulkhead
Stick 60% — N —4 Stem	100	300	7 000	7 400	10 842	50	NR	NR	NR	NR	NR	NR	No		Scrapers			
Stick 65% — N —4 Stem	100	1 250	3 500	4 850	7 656	62	NR	NR	NR	NR	NR	NR	No					
Stick 40% — N —4 Stem	0	1 160	11 420	12 600	16 992	63	119	24	30	25	38	0	No				Fort Riley A B C D E OKETO	
Stick 40% — N —4 Stem	0	300	6 850	7 150	13 200	60	37	25	25	25	44	0	No					
Stick 40% — N —4 Stem	0	1 350	6 600	7 950	14 000	50	NR	NR	NR	NR	NR	NR	No	Overshot Fine		Sh and Ls Fill	Blue Springs Shale A B	
Stick 40% — N —4 Stem	0	200	6 900	7 100	14 000	50	17	26	22	20	41	0	No	Overshot Fine				

MILFORD DAM BLASTING RECORD — TABLE 6

IVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn	Lbs A N	Total Explos	Est Yd Rock	Lbs Yd	CAPS – DELAYS I	1	2	3	4	5	PRIMA CORD	RESULTS	METHOD OF EXCAV	UTILIZATION	GEOLOGIC F M	REMARKS
1/S 40% N —4 Stem	0	800	2 500	3 300	6 770	49	0	30	15	15	20	0	No	Overshot Fine	Scrapers	Sh and Ls Fill	Blue Springs Sh A B	
1/S 40% N —4 Stem	0	600	3 300	3 900	7 280	53	0	30	20	15	26	0	No	Overshot Fine	Scrapers	Sh and Ls Fill	Blue Springs Sh A B	
1/S 40% N —4 Stem	0	800	100	900	2 560	35	12	20	0	0	0	0	No	Overshot Fine	Scrapers	Sh and Ls Fill	Blue Springs Sh A B	
—																		No data
Dyn — 2 Stem	0	125	0	125	280	4	0	0	20	27	0	0	No	Good		Sh and Ls Fill	Blue Springs Zone B	U and D surfaces for this area were line drilled
1S 40% —4 Stem	0	100	1.200	1 300	1 722	7	NR	NR	NR	NR	NR	NR	No	Good	NORTHWEST 95 SHOVEL AND DRAGLINE	Sh and Ls Fill	Blue Springs Zone B	
40% or 60% —4 Stem	500	250	1.246	1 996	2 800	7	37	21	22	0	0	0		Good		Sh and Ls Fill	Blue Springs Zone B	
60% — —4 Stem	50	0	700	750	1.596	5	10	10	18	0	0	0	-	Good		Sh and Ls Fill	Blue Springs Zone B	
or 60% — —4 Stem	1.000	100	1.500	2.600			1	22	25	0	0	0	1.000	Overbreak on Slopes		Sh and Ls Fill	Blue Springs Zone B	
—6 Stem	300	100	0	400	1 700	2	40	30	30	0	0	0	No	Overbreak on Slopes		Sh and Ls Fill	Kinney Ls and Upper Wyamore Sh	
—40% — 6 Stem	0	2 200	0	2 200	2 975	7	1	2	2	2	0	0	3.800	Good		Sh and Ls Fill	Kinney Ls and Upper Wyamore Sh	
as above	1 400	300	0	1.700	3 080	5	23	15	14	18	0	0	2 700	Excellent Breakage		Sh and Ls Fill	Kinney Ls and Upper Wyamore Sh	
as above	500	100	0	600	1 166	6	9	12	13	13	3	0	500	Good		Sh and Ls Fill	Kinney Ls and Upper Wyamore Sh	
as above	800	100	0	900	1 386	6	16	14	16	17	0	0	Yes	Fair		Sh and Ls Fill	Wyamore B	
as above	0	(65%) 2 500	0	2 500	2 Shots	X	2	1	3	1	1	0	2.000	Good		Sh and Ls Fill	Wyamore B	2 shots tied together — shot holes too deep in area of O G section

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

BLASTING RECORD TABLES 4, 5 AND 6

In 1 sheet — Sheet No 1 — Not to scale

CORPS OF ENGINEERS U. S. ARMY

KANSAS CITY DISTRICT

FILE NO. 8-1-1951

APRIL 1977

MILFORD DA[illegible]

	SHOT #	DATE	SECTION	LIFT	LOCATION	Equipment	Hole Dia	Depth	DRILLING Pattern	Angle	Slope	No of Holes	ELEVATION Surface El	Bottom El	EXPLOSIVE COLUMN	Lbs 60% Dyn	Lbs 40% Dyn	Lb[illegible]
OUTLET WORKS	91	4 20 63	Stilling Basin	5th Lift	Sta 4+30 4+73 D	Rotary	4 [illegible]	[illegible]	[illegible] X 8	Vertical	1 on 0 5	52			[illegible] Sticks [illegible] Stem		200	
	92	4 23 63			Sta 4+73 92 D	Rotary	4 [illegible]	[illegible]	9 X 12	Vertical	1 on 0 5	103			[illegible] Sticks 6 Stem		[illegible] 400	
	93	4 23 63			Sta 4+73 5+92 D	Rotary	4 [illegible]	[illegible]	8 X 11	Vertical	1 on 0 5	83	1 045 +	1 [illegible]	[illegible] Sticks 6 Stem		45% [illegible] 350	
	94	4 24 63			Sta 5+00 6+00 D	Rotary	4	10 [illegible]	6 X 8	Vertical	1 on 0 5	63			[illegible] Sticks 6 Stem		45% [illegible] 100	
	95	4 25 63			Sta 4+73 5+92 D	Rotary	4 [illegible]	10 0	6 X 8	Vertical	1 on 0 5	83			[illegible] Sticks 6 Stem		45% [illegible] 200	
	96	5 1 63			Sta 4+73 5+00 D	Rotary	4 [illegible]	6 0	5 X 5	Vertical	1 on 0 5	30	1 035 +	1 029 +	6 Sticks [illegible] Stem	[illegible]	100	
	97	5 4 63			Sta 5+20 5+00 D	Rotary	4 [illegible]	[illegible] 0	[illegible] X [illegible]	Vertical	Vertical	447		Stilling Basin	1 Stick [illegible] Mud Stem	[illegible]	350	
	98	5 7 63			Sta 5+20 5+60 D	Rotary	4 [illegible]	2 0	[illegible] X [illegible]	Vertical	Vertical	715	1 033 +	1 031 + Grade	1 Stick [illegible] Mud Stem	[illegible]	500	
	99	5 9 63			Sta 5+60 6+00 D	Rotary	4[illegible]	[illegible] 0	[illegible] X [illegible]	Vertical	Vertical	647			1 Stick [illegible] Mud Stem	0	400	
	100	5 26 63	END		Sta 6+00 D	Air Trac	2[illegible]	10 0	36 C to C	Vertical	Vertical	30	1 044 +	[illegible] 034 +	1 Stick per foot	[illegible]	[illegible]50	
	101	5 27 63	SILL		Sta 5+99 D	Air Trac	2[illegible]	10 0	36 C to C	Vertical	Vertical	30	1 044 +	1 034 +	1 Stick per foot	[illegible]	250	
QUARRY	102	5 27 63	Quarry			Air Trac	2 [illegible]	4 5	8 x 12	Vertical	Vertical	120	1 132 +	1 128 +	6 Sticks 3 Stem	400	[illegible]	
	103	5 28 63	Area			Air Trac	2[illegible]	4 5	8 x 12	Vertical	Vertical	365	1 132 +	1 128 +	2 Sticks 2 Stem	300	[illegible]	3,[illegible]
	104	5 29 63	A			Rotary	4[illegible]	12 0	11 x 16	Vertical	Vertical	87	1 140 +	[illegible] 128 +	1 Stick 60% A N 4 Stem	[illegible]00	[illegible]	2,[illegible]

MILFORD DAM BLASTING RECORD - TABLE 7

COLUMN	LOADING: Lbs 60% Dyn	Lbs 40% Dyn	Lbs A N	Total Expos	Est Yd Rock	LBS/Yd	CAPS DELAYS: 0	1	2	3	4	PRIMA CORD	RESULTS	METHOD OF EXCAV	UTILIZATION	GEOLOGIC FM	REMARKS
Stem	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	No	Good			Wyamore B	
Stem		[illegible]		[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	Good				
Stem		[illegible]	[illegible]	[illegible]	460		[illegible]	[illegible]	[illegible]			[illegible]	Good	Northwest of Shovel and Dragline			[illegible] hole loaded due to error into end [illegible] shot separately
Stem	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	Good		Shale and Limestone Fill		
Stem		[illegible]	[illegible]	[illegible]	[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Breakage Good				
Stem	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	18	[illegible]	No	Good			Schroyer	
ed Stem	[illegible]	[illegible]	[illegible]	350	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	Good			LS	Adobe Shooting - Stilling Basin floor grade 0.5 or [illegible]
ed Stem	[illegible]	500	[illegible]	500	[illegible]	4	4		[illegible]		[illegible]	[illegible]	Good				Adobe Shooting Stilling Basin floor
ed Stem	[illegible]	400	[illegible]	400	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Good				Adobe Shooting Stilling Basin floor
Foot	[illegible]	[illegible]	[illegible]	[illegible]			3	[illegible]	[illegible]	[illegible]	[illegible]	Yes	Good Pre Split Surface				Adobe Shooting Stilling Basin floor
Foot	[illegible]	250	[illegible]	250			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Yes	Good Pre Split Surface				Adobe Shooting Stilling Basin floor
Stem	400	[illegible]	[illegible]	400	[illegible]	[illegible]	NR	NR	NR	NR	NR	5,000	Good	Marion			
Stem	400	[illegible]	3,800	4,100	6,228	[illegible]	NR	NR	NR	NR	NR	No	Good	Shovel	Riprap	Fort Riley	
Stem	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	NR	NR	NR	NR	NR	No	Good				

REPUBLICAN RIVER, KANSAS

MILFORD LAKE

FOUNDATION REPORT

BLASTING RECORD
TABLE 7

In 1 sheet | Sheet No 1 | Not to scale

CORPS OF ENGINEERS U. S. ARMY
KANSAS CITY DISTRICT

FILE NO. 8-1-1952
APRIL 1977

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Milford Dam Test Data on Bedrock Strata — Table 8

Bedrock Unit	Rock Type	Unconfined Compression tons/ft²				Dry Weight lbs/ft³		Moisture Content % dry wt.		Wetting-Drying			Modulus of Elasticity (Tan) (PSI)*			
											Average					
		No. Tests	Avg.	Max.	Min.	No. Tests	Avg.	No. Tests	Avg.	No. Tests	% loss	Cycles	No. Tests	Avg.	Max.	Min.
Towanda Limestone	Ls	4	122	318	21	6	122	6	15	3	33	14	4	4.0	11.0	0.4
	Sh	1	5			2	106	2	23	1	100	1	1	0.1		
Holmesville Shale	Ls	1	33			1	143	1	6	0			1	7.0		
	Sh	18	25	110	1	23	124	23	13	16	100	1	18	0.4	2.0	0.01
Ft. Riley Limestone																
Zone A	Ls	17	111	288	25	19	123	19	14	5	60	9	17	4.0	10.0	0.5
	Sh	3	29	68	7	4	128	4	13	1	100	1	3	3.0	6.0	0.1
Zone B	Ls	11	150	456	4	12	131	12	11	0			11	7.0	19.0	2.0
Zone C	Ls	25	333	545	135	25	146	25	6	4	0	20	25	6.0	14.0	0.2
Zone D	Ls	20	127	244	55	21	122	21	13	2	50	15	20	5.0	14.0	0.04
Zone E	Ls	3	127	162	95	3	144	3	6	0			3	3.0	4.0	0.1
Oketo Shale	Sh	15	253	390	131	15	152	15	4	0			15	4.0	7.0	2.0
Florence Limestone																
Zone A	Ls	1	229			1	141	1	6	0			1	7.0		
Zone B	Ls	1	131			1	132	1	10	0			1	5.0		
Zone C	Ls	1	84			1	121	1	14	0			1	3.0		
Zone D	Ls	0				0		0		0			0			
Blue Springs Shale																
Zone A	Sh	2	47	74	20	3	139	3	9	4	100	2	2	0.9	1.0	0.7
Zone B	Sh	4	70	172	19	4	139	4	9	4	100	2	4	1.5	3.0	0.1
Kinney Limestone	Ls	4	338	444	188	4	148	4	5	0			4	8.0	14.0	3.0
Wymore Shale	Sh	6	160	289	44	8	137	8	8	6	100	3	5	3.0	6.0	1.0

*Note: All modulus of elasticity values are x10^5.

MILFORD DAM, PRESSURE TEST DATA - TABLE 9

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-235	Spillway	1215.8	1199.3	1195.8 - 1190.8	Towanda Ls.	26	5	2.2
				1190.8 - 1185.8	Towanda Ls.	30	5	5.1
				1185.8 - 1180.8	Towanda Ls. and Holmesville Sh.	35	3	7.0
				1180.8 - 1175.8	Holmesville Sh.	40	1	0.0
				1175.8 - 1170.8	Holmesville Sh.	45	5	0.5
				1170.8 - 1165.8	Holmesville Sh. and Ft. Riley Ls.	51	3	4.5
				1165.8 - 1160.8	Ft. Riley Ls. (Zone A)	55	3	5.0
				1163.8 - 1158.8	Ft. Riley Ls. (Zone A)	58	2	8.1
				1158.8 - 1153.8	Ft. Riley Ls. (Zones A & B)	62	5	0.1
				1153.8 - 1148.8	Ft. Riley Ls. (Zone B)	67	5	0.6
				1148.8 - 1143.8	Ft. Riley Ls. (Zone C)	No Test		

*Water used recorded in GPM per foot of section tested.

MILFORD DAM, PRESSURE TEST DATA - TABLE 9 (CONTINUED) Sheet 2 of 7

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-235	Spillway	1215.8	1199.3	1143.8 - 1138.8	Ft. Riley Ls. (Zones C & D)	77	5	7.0
				1138.8 - 1133.8	Ft. Riley Ls. (Zone D)	82	5	7.5
				1133.8 - 1128.8	Ft. Riley Ls. (Zones D & E) and Oketo Sh.	88	5	6.1
DC-236	Spillway	1229.3	1201.4	1201.3 - 1196.3	Gage Sh. and Towanda Ls.	28	5	1.3
				1196.8 - 1191.8	Towanda Ls.	33	5	0.6
				1191.8 - 1186.8	Towanda Ls.	38	5	6.5
				1186.8 - 1181.8	Towanda Ls. and Holmesville Sh.	43	5	3.9
				1181.8 - 1176.8	Holmesville Sh.	48	5	0.7

MILFORD DAM, PRESSURE TEST DATA - TABLE 9 (CONTINUED)

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-236	Spillway	1229.3	1201.4	1176.8 - 1171.8	Holmesville Sh.	53	3.5	9.6
				1171.8 - 1166.8	Holmesville Sh. and Ft. Riley Ls. (Zone A)	58	4	9.2
				1166.8 - 1161.8	Ft. Riley Ls. (Zone A)	63	5	7.2
				1161.8 - 1156.8	Ft. Riley Ls. (Zone A)	68	4	7.0
				1156.8 - 1151.8	Ft. Riley Ls. (Zone B)	73	2	10.9
				1151.8 - 1146.8	Ft. Riley Ls. (Zones B & C)	78	5	0.9
				1146.8 - 1141.8	Ft. Riley Ls. (Zone C)	83	5	2.3
				1141.8 - 1136.8	Ft. Riley Ls. (Zone D)	88	2	10.0
				1136.8 - 1131.8	Ft. Riley Ls. (Zones D & E) and Oketo Sh.	92.5	2	7.0

MILFORD DAM, PRESSURE TEST DATA - TABLE 9 (CONTINUED)

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-289 (Angle boring 45° from vertical)	Right Abutment	1200.7	1199.0	1179.5 - 1176.0	Holmesville Sh.	21	5	4.1
				1176.0 - 1172.5	Holmesville Sh.	25	5	4.7
				1172.5 - 1169.0	Ft. Riley Ls. (Zone A)	28	5	4.2
				1169.0 - 1165.5	Ft. Riley Ls. (Zones A & B)	32	5	4.0
DC-290 (Angle boring 26° from vertical)	Left Abutment	1163.7	1162.2	1156.5 - 1154.7	Ft. Riley Ls. (Zone B)	8	5	7.8
				1147.5 - 1145.7	Ft. Riley Ls. (Zones C & D)	18	5	4.4
				1138.5 - 1136.7	Ft. Riley Ls. (Zone D)	28	5	8.3
				1129.5 - 1127.7	Oketo Sh. and Florence Ls.	38	5	0.3
				1120.6 - 1118.8	Florence Ls. (Zone A)	48	5	0.3
				1111.5 - 1109.7	Florence Ls. (Zone B)	58	5	12.6

MILFORD DAM, PRESSURE TEST DATA - TABLE 9 (CONTINUED)

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-290 (Angle boring 26° from vertical)	Left Abutment	1163.7	1162.2	1102.6 - 1100.8	Florence Ls. (Zone C)	68	5	1.1
				1093.7 - 1091.9	Blue Springs Sh.	78	5	1.1
DC-301 (Angle boring 32° from vertical)	Right Abutment	1201.7	1200.2	1197.5 - 1189.2	Towanda Ls.	7	5	1.5
				1187.7 - 1181.3	Holmesville Sh.	14	5	1.7
				1181.4 - 1172.3	Holmesville Sh. & Ft. Riley Ls. (Zone A)	24	5	2.0
				1172.5 - 1168.3	Ft. Riley Ls. (Zone A)	34	5	4.7
				1168.3 - 1156.2	Ft. Riley Ls. (Zone B)	34	5	0.8
				1156.8 - 1149.6	Ft. Riley Ls. (Zones B & C)	46	5	2.7
				1149.6 - 1142.7	Ft. Riley Ls. (Zones C & D)	53	5	2.9

MILFORD DAM, PRESSURE TEST DATA - TABLE 9 (CONTINUED)

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-301 (Angle boring 32° from vertical)	Right Abutment	1201.7	1200.2	1143.2 - 1135.6	Ft. Riley Ls. (Zones D & E)	60	5	2.7
				1138.0 - 1133.7	Ft. Riley Ls. (Zones D & E)	65	5	0
				1133.7 - 1129.5	Oketo Sh.	69	5	1.3
				1129.5 - 1125.2	Florence Ls. (Zone A)	74	5	1.6
				1125.2 - 1121.1	Florence Ls. (Zone A)	78	5	1.8
				1121.1 - 1111.0	Florence Ls. (Zones A & B)	82	5	1.1
				1111.0 - 1102.4	Florence Ls. (Zones B & C)	93	5	2.8
				1102.4 - 1094.0	Florence Ls. (Zone D) and Blue Springs Sh.	99	5	0.0

MILFORD DAM, PRESSURE TEST DATA - TABLE 9 (CONTINUED)

HOLE	LOCATION	SURFACE ELEVATION	TOP ROCK ELEVATION	ELEVATIONS TESTED	BEDROCK UNIT	ACTUAL PRESSURE (PSI)	LENGTH OF TEST (MIN.)	WATER* USED (GPM)
DC-302 (Angle boring 24° from vertical)	Left Abutment	1162.3	1160.5	1156.8 - 1155.0	Ft. Riley Ls. (Zone B)	6	5	0.9
				1148.7 - 1146.3	Ft. Riley Ls. (Zone C)	16	5	4.6
				1138.5 - 1136.8	Ft. Riley Ls. (Zone D)	26	5	1.5
				1129.4 - 1127.6	Oketo Sh.	36	5	10.9
				1120.3 - 1118.5	Florence Ls. (Zone A)	46	5	11.1
				1111.2 - 1109.3	Florence Ls. (Zone A)	56	5	11.5
				1102.1 - 1100.3	Florence Ls. (Zone C)	66	5	2.7

MILFORD DAM, Summary of Test Grouting - TABLE 10
Feb-Nov 1962

Right Abutment Sta 82+20 to Sta 88+64

	Lineal feet Drilled	Sacks of Cement injected
18 Primary holes	2,180	3,825
17 Secondary holes	2,051	959
34 Tertiary holes	4,094	1,382
16 Quaternary holes	1,374	231
11 Angle holes	1,369	290.5
96 total	11,068*	6,687.5
	7,876 (Net)	0.849 sack/lineal ft.

*Includes 676 lineal feet of overburden and 2,516 lineal feet of horizons not grouted, (Ft. Riley zones C and E and Oketo Shale and Blue Springs Shale).

Left Abutment Sta 143+00 to Sta 151+00

	Lineal feet Drilled	Sacks of Cement injected
21 Primary holes	2,255	3,846
20 Secondary holes	2,160	1,824
40 Tertiary holes	4,278	984
34 Quaternary holes	1,366	184
2 Quinary holes	47	4
5 Angle holes	602	47.75
122 total	10,708*	6,889.75
	6,942 (Net)	0.992 sacks/lineal ft.

*Includes 874 lineal feet of overburden and 2,892 lineal feet of horizons not grouted, (Ft. Riley zones C and E and Oketo Shale and Blue Springs Shale).

MILFORD DAM, Summary of Contract Grouting - TABLE 11
Feb-Nov 1963

Right Abutment Sta 88+25 to Sta 90+80

	Lineal feet Drilled	Sacks of Cement injected
35 Primary holes	1,812.1	799
25 Secondary holes	1,065.1	197
20 Tertiary holes	572.9	0
80 total	3,450.1	996
		0.289 sacks/lineal ft.

Left Abutment Sta 142+07 to Sta 143+72

	Lineal feet Drilled	Sacks of Cement injected
19 Primary holes	1,126.1	115
17 Secondary holes	1,064.8	49
5 Tertiary holes	226.8	14
41 total	2,417.7	178
		0.074 sacks/lineal ft.

PHOTOGRAPHS

PHOTOGRAPHS

1. Milford Dam, October 1962, Neg. No. 294-P4-3. Laborers making up "pig tails" for pre-split blasting.

2. Milford Dam, October 1962, Neg. No. 294-P4-2. Loading 45° angle holes for pre-split blasting.

3. Milford Dam, October 1962, Neg. No. 294-P4-5.
Test shot results for pre-split blasting.

4. Milford Dam, October 1962, Neg. No. 294-P4-4. Pre-split fracture with primary drilling in progress.

5. Milford Dam, November 1962, Neg. No. 294-P4-1. Pre-split back slope first lift left abutment cutoff.

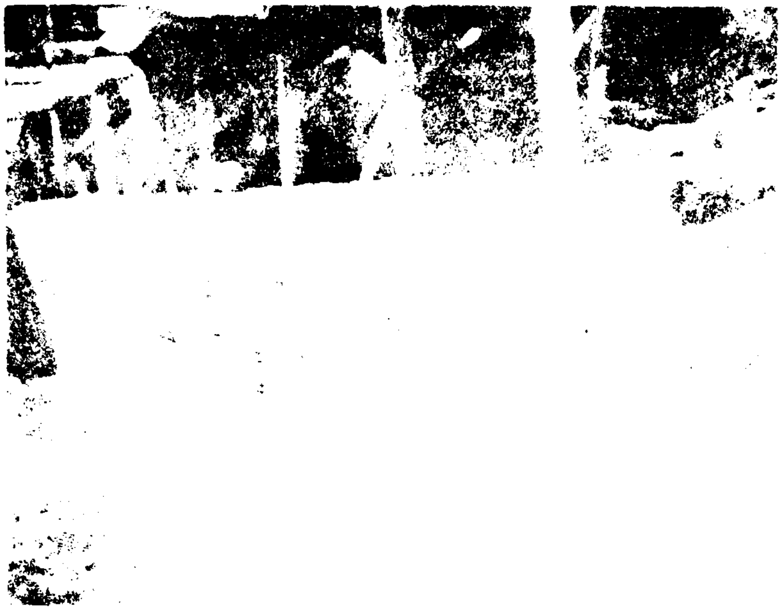
6. Milford Dam, November 1962, Neg. No. 294-P3-16. Pre-split right abutment cutoff.

7. Milford Dam, November 1962, Neg. No. 294-P3-15.
Profile of pre-split slope, left abutment cutoff.

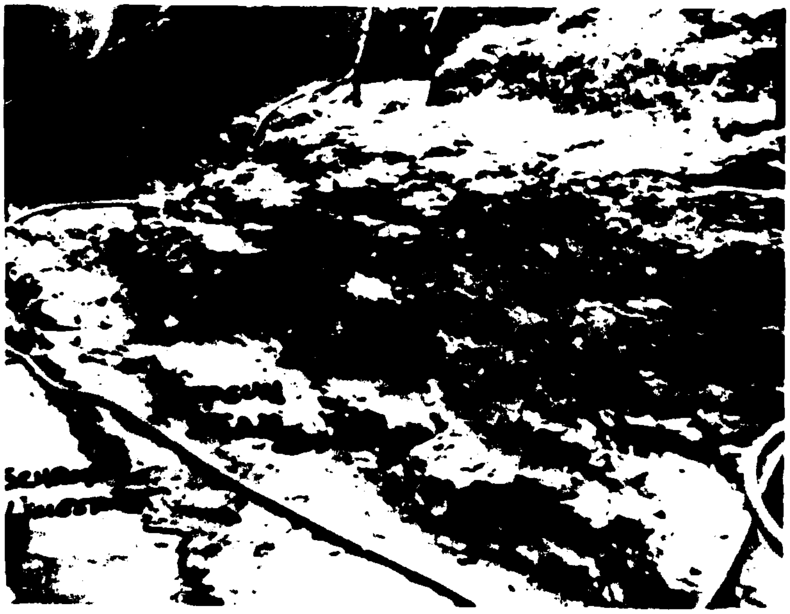
8. Milford Dam, November 1962, Neg. No. 294-P1-13.
Gypsum seam in lower Wymore.

9. Milford Dam, November 1962, Neg. No. 294-P3-2. Approach slab foundation Blue Springs shale zone "A" station 3+96U to station 3+76U.

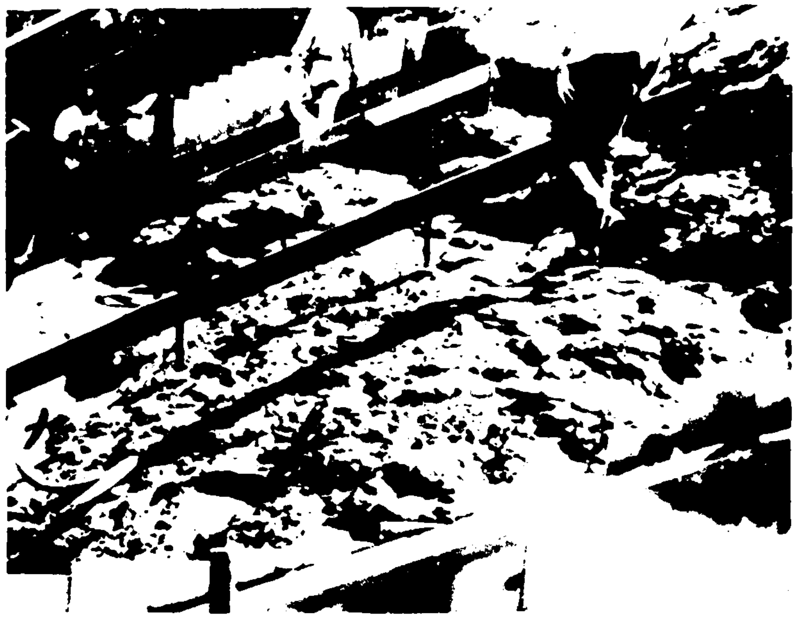
10. Milford Dam, November 1962, Neg. No. 294-P1-14. Foundation of south approach wall, station 4+55U to station 3+96U.



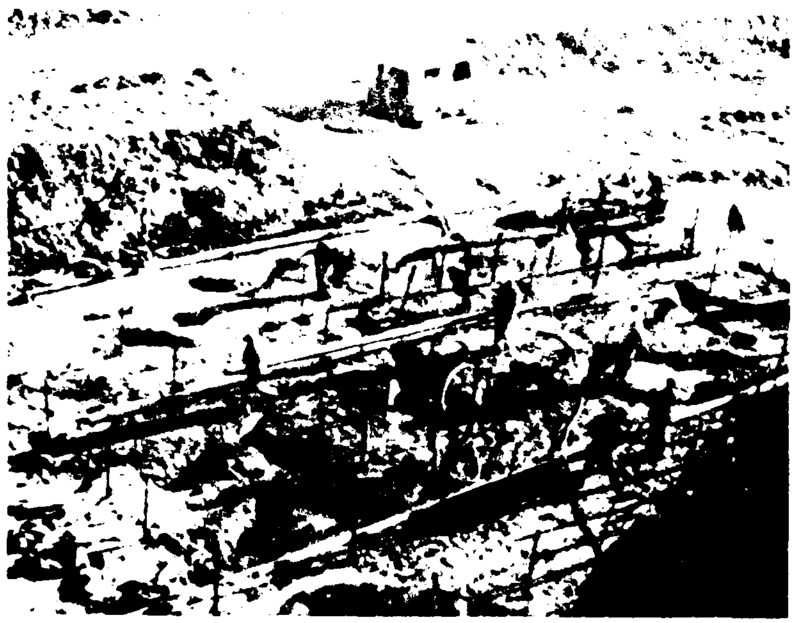
11. Milford Dam, November 1962, Neg. No. 294-P3-1. Tower key vertical surface at station 3+76U.



12. Milford Dam, November 1962, Neg. No. 294-P1-10. O.G. station foundation from station 4+50D to station 4+75D, landward side, Wymore shale zone "B".



13. Milford Dam, November 1962, Neg. No. 294-P1-11. O.G. section foundation from station 4+50D to station 4+75D, landward side, Wymore shale zone "B".



14. Milford Dam, November 1962, Neg. No. 294-P2-13. Tower foundation station 3+14U to station 2+63U.

15. Milford Dam, November 1962, Neg. No. 294-P2-14. Tower key foundation station 3+76U to station 3+46U Blue Springs shale zone "B".

16. Milford Dam, November 1962, Neg. No. 294-P2-16. Typical conduit foundation in Blue Springs shale zone "B".

17. Milford Dam, November 1962, Neg. No. 294-P2-15. Conduit collar excavation in Blue Springs shale zone "B".

18. Milford Dam, November 1962, Neg. No. 294-P3-3. Typical cleavage plane encountered in the "B" zone of the Blue Springs shale.

19. Milford Dam, November 1962, Neg. No. 294-P2-2. Foundation for O.G. section in Wymore shale zone "A".

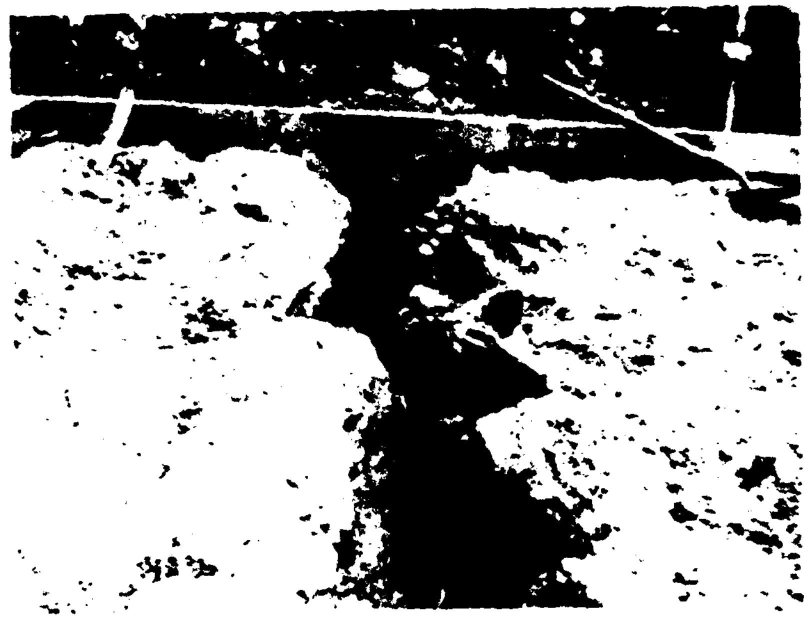
20. Milford Dam, November 1962, Neg. No. 294-P2-4. End sill vertical surface at station 6+02D, Schroyer limestone, upper section of surface is protected with gunite (Wymore shale).

21. Milford Dam, November 1962, Neg. No. 294-P2-3. Closeup of end sill vertical surface. Line drill holes are 3 inch OD. White masses are gypsum.

22. Milford Dam, November 1962, Neg. No. 294-P1-2. Stilling basin foundation from station 4+73D to station 4+93D, Schroyer limestone.

23. Milford Dam, November 1962, Neg. No. 294-P1-1. Stilling basin foundation, station 5+52D to station 5+77D, Schroyer limestone.

24. Milford Dam, November 1962, Neg. No. 294-P2-12. Workman deroofing joint opening under approach slab foundation.



25. Milford Dam, November 1962, Neg. No. 294-P2-11.
Joint in approach slab foundation after clean-up,
Blue Springs shale zone "A".

26. Milford Dam, March 1963, Neg. No. 294-P2-9.
Looking down on tower area from top of cut. The
dark depressions are joint openings after clean-up

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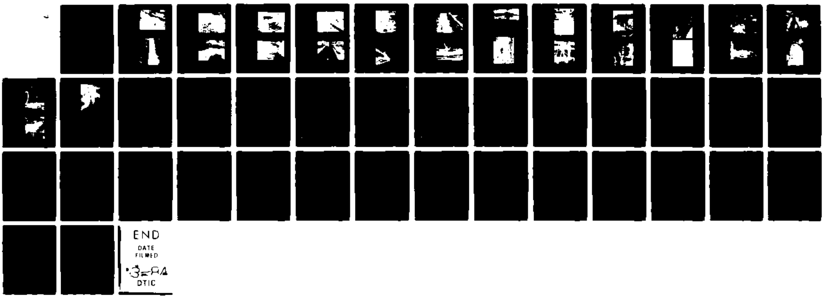
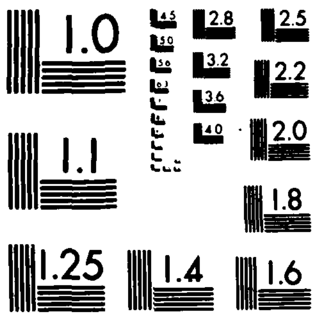




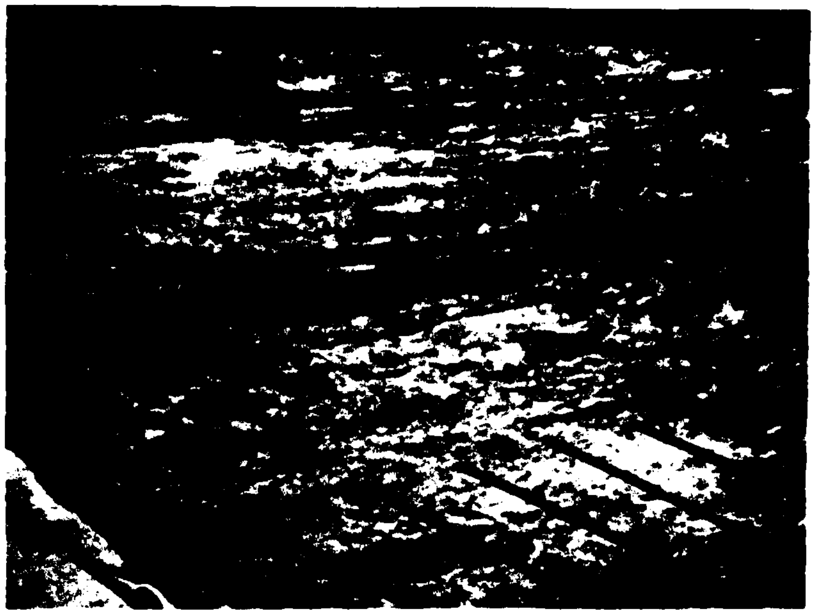
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

27. Milford Dam, March 1963, Neg. No. 294-P2-10. Tower area showing joint depressions after cleanup.

28. Milford Dam, March 1963, Neg. No. 294-P1-16. Sill key (upstream) excavation. Note wire mesh on vertical walis in foreground, workman is spraying gunite in background.

29. Milford Dam, March 1963, Neg. No. 294-P2-1. Typical foundation for crest slab in lower Holmesville shale.

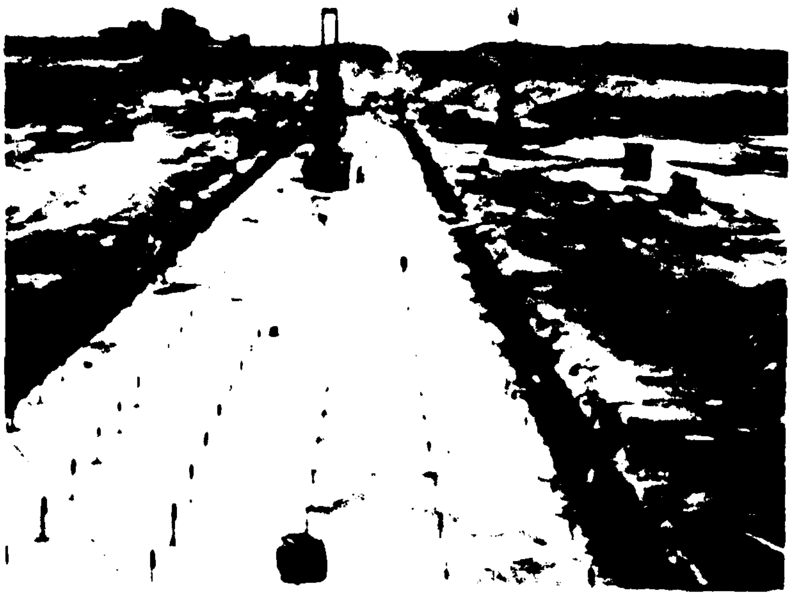
30. Milford Dam, April 1963, Neg. No. 294-P1-5. Typical foundation for crest slab.



31. Milford Dam, April 1963, Neg. No. 294-P1-6.
Typical foundation for crest slab.

32. Milford Dam, April 1963, Neg. No. 294-P1-7.
Slope foundation for crest slab in Holmesville
shale.

33. Milford Dam, April 1963, Neg. No. 294-P2-5. Slope foundation for crest slab in Towanda limestone. Note grouted anchors. Screeds are set for backfill concrete due to overexcavation.

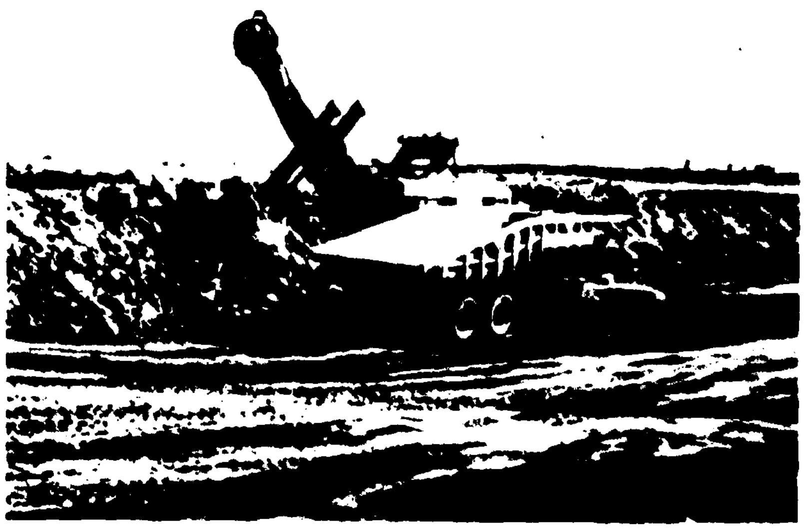


34. Milford Dam, May 1963, Neg. No. 294-P2-6. Work in progress in sill area. Grouted anchors are set through lean slab in foreground while rotary drills anchor holes in background.

35. Milford Dam, May 1963, Neg. No. 294-P3-10. Placing grouted anchors through lean concrete pad in crest slab area.

36. Milford Dam, May 1963, Neg. No. 294-P3-9. Air track drills drilling angle holes for anchors in key for shale protection slab.

37. Milford Dam, June 1963, Neg. No. 294-P1-12. Shale protection slab key excavation with grouted anchors in place.



38. Milford Dam, June 1963, Neg. No. 294-P2-7. Electric powered Marion shovel excavating spillway rock in 80 cubic yard end dump truck.

39. Milford Dam, June 1963, Neg. No. 294-P2-8. Hauling equipment used for rock excavation. The front truck was the type primarily used with a capacity of 30 cubic yards. The truck in the rear has a capacity of 80 cubic yards.

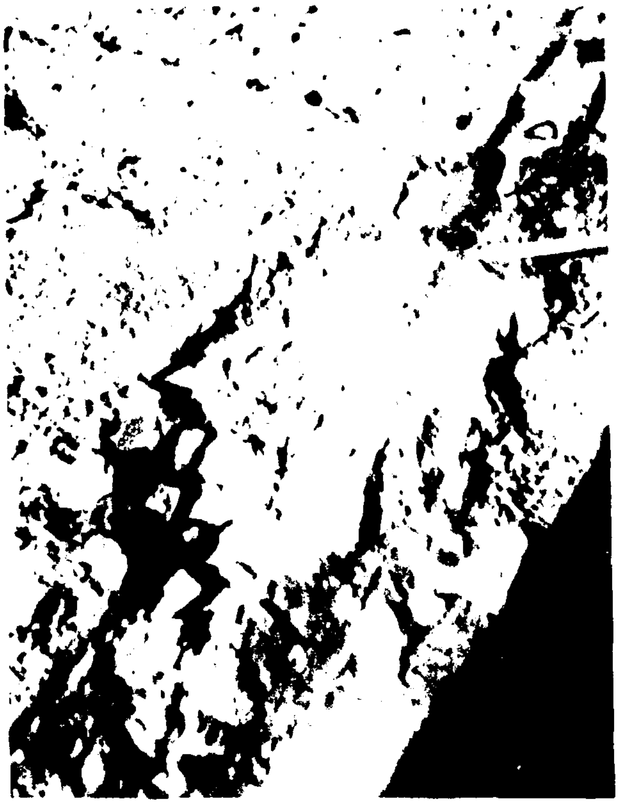
40. Milford Dam, July 1963, Neg. No. 294-P1-3. The middle zone of the Towanda limestone which produced the better quality rock from the spillway excavation.

41. Milford Dam, July 1963, Neg. No. 294-P1-4. The two lower zones of the Towanda limestone. Note the clay filled solutioned zone.

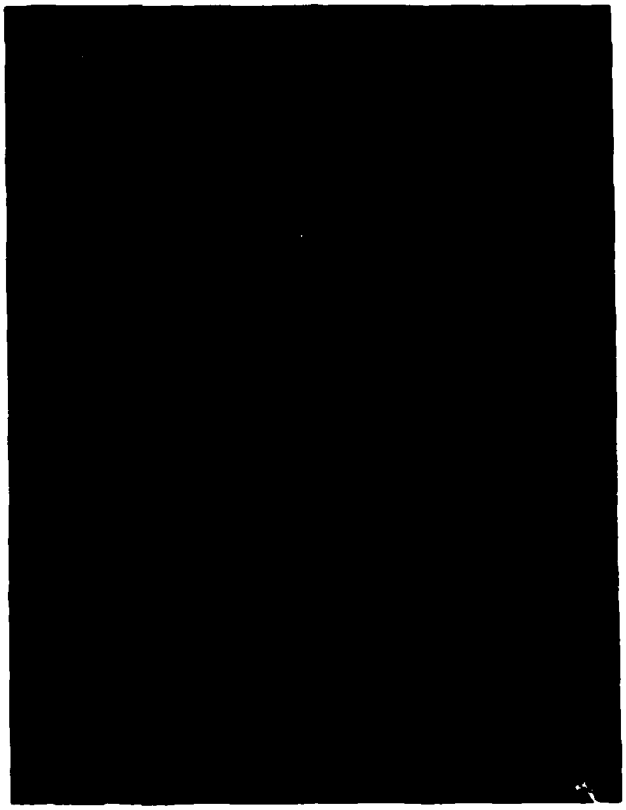
42. Milford Dam, July 1963, Neg. No. 294-P3-7. Drilling grout hole with CP 65 drill.

43. Milford Dam, July 1963, Neg. No. 294-P3-6. Pressure hole.

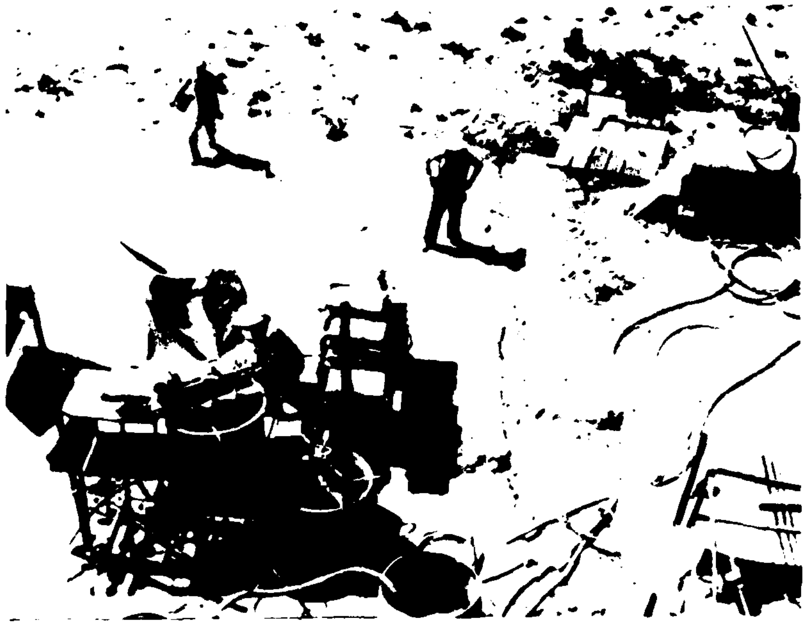
44. Milford Dam, July 1963, Neg. No. 294-P3-8. Washing grout hole with air-water.



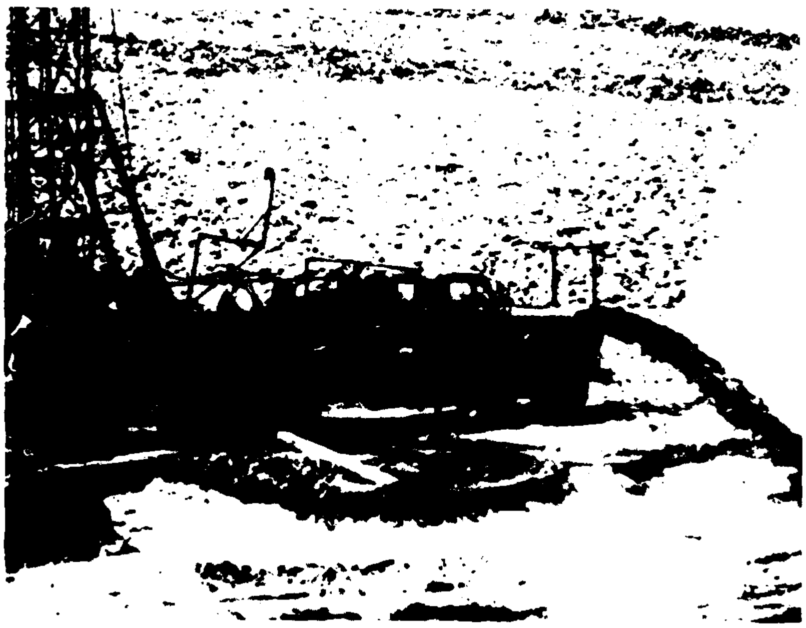
45. Milford Dam, July 1963, Neg. No. 294-P3-5. Grout filled joint at station 0+46U in conduit foundation.



46. Milford Dam, July 1963, Neg. No. 294-P3-4. Grout filled joint at station 0+46U in conduit foundation.

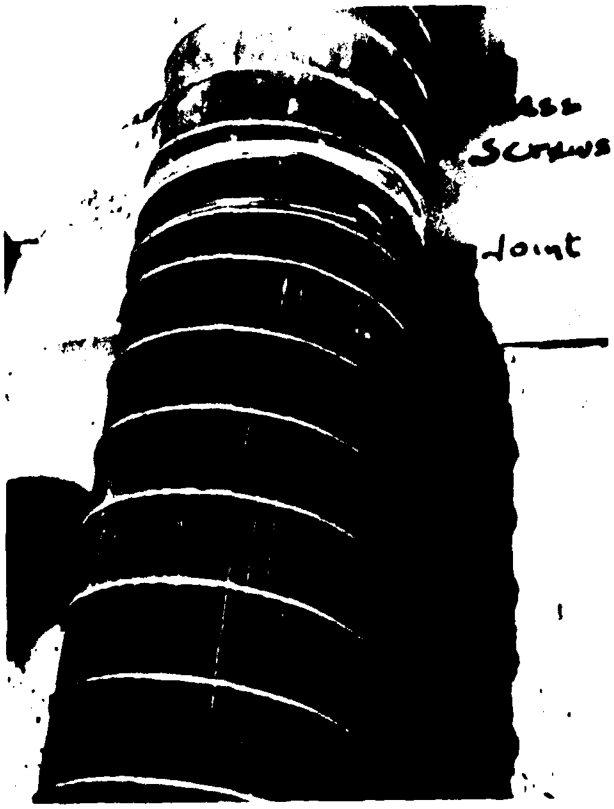


47. Milford Dam, July 1963, Neg. No. 294-P1-15
Grout plant used in grouting operations.

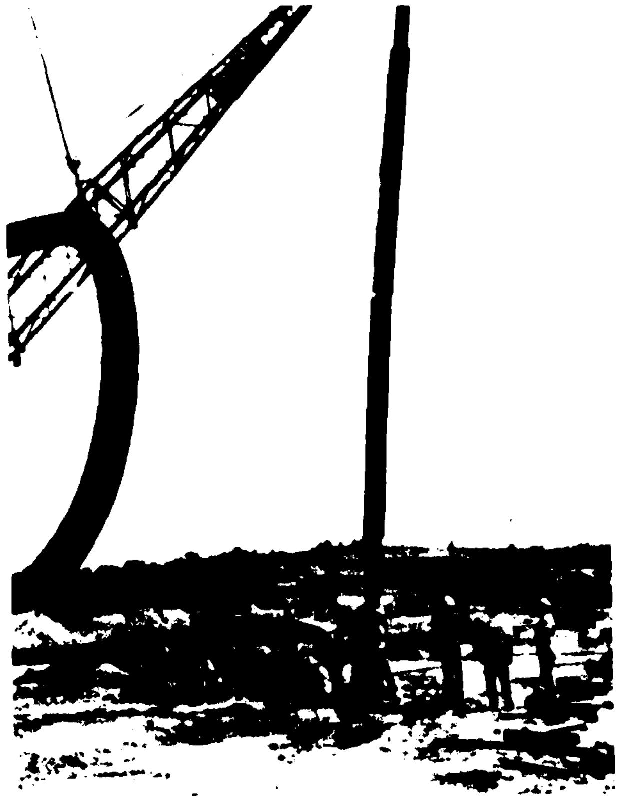


48. Milford Dam, July 1963, Neg. No. 294-P1-8.
Reverse rotary drill rig used to drill relief wells.

49. Milford Dam, July 1963, Neg. No. 294-P1-9. Drill bit (24" dia.) used during reverse rotary drilling.



50. Milford Dam, August 1963, Neg. No. 294-P3-12. Close-up of screen and riser joint in wood section.



51. Milford Dam, August 1963, Neg. No. 294-P3-11. Placement of screen and riser into well by crane.

52. Milford Dam, August 1963, Neg. No. 294-P3-13. Completed makeup of wood screen and riser. Note positions.

53. Milford Dam, August 1963, Neg. No. 294-P3-14. Pump being used to develop relief well by over-pumping.

SUPPLEMENT A

SUPPLEMENT A

SUPPLEMENT A

INSTALLATION OF ABUTMENT GROUT CURTAINS, MILFORD DAMSITE

A-01. General. In accordance with authorization from O.C.E., experimental drilling and grouting operations were initiated by hired labor crews 1 February 1962 on the right abutment of Milford damsite. The objectives were as follows: (1) To determine whether installation of a satisfactory grout curtain could be accomplished by means of vertical holes instead of angle holes. (2) To determine whether grout holes of NX size could be more economically drilled by use of air as the drilling fluid. (3) To determine which type of drill bit could perform the drilling with the greatest economy. All vertical holes were drilled and grouted in accordance with the "stop" method, in which each hole is drilled to full depth and then pressue tested and grouted by means of packer settings made at successively shallow depths in the hole until the highest zone encountered in the hole has been grouted. On completion of the grouting of any vertical hole in this manner, the hole was immediately backfilled with suitably heavy grout. No casing was used except in holes drilled thru the sand that overlies the landward 360 feet of the left abutment experimental grout curtain. All holes were of standard NX size. A total of 16 angle holes, all inclined at an angle of 20 degrees with the vertical, were drilled for the purpose of ascertaining the effectiveness of the vertical-hole type of grouting. Pressures used in the pressure testing and the grouting were generally (but not always) in the range of 1.5 and 2.0 pounds per foot of vertical depth. This includes so-called column pressure. Generally, the gate pressure at the grout header would register as many pounds as the distance in feet between the ground surface and the bottom of the inflated packer. When grout, "takes" were very rapid, there was no attempt made to maintain what would constitute a maximum allowable pressure. Higher pressures, up to 3.0 pounds per foot of vertical depth, were often applied when the grout injection rate appeared to be much lower than the grout injection rate that had been indicated as probable by the pressure testing. Final grouting pressures were generally in the high range unless a very large volume of grout had been injected, in which case the possibility of "jacking" the rock was taken into careful account, for the greater the volume of grout injected, the greater the danger of "jacking."

A-02. Spacing of Grout Holes Because the "stop" method of grouting was employed, hole-to-hole communication of water or grout was carefully avoided. Primary holes were drilled and grouted at 80-foot intervals, and then a second set of primary holes was drilled and grouted at intervals midway between the initial set of primary holes. Thus the primary holes, though actually drilled at 80-foot intervals, were finally spaced at 40-foot intervals along the two experimental grout curtains. The secondary holes were spaced in exactly the same manner as were the primary holes, except in cases involving the possibility of interference with contractors' operations in the immediate area. In such cases, the drilling and grouting sequence was altered to avoid interference.

Tertiary holes were also drilled and grouted at 80-foot intervals initially, and were not drilled at 40-foot intervals until the last "pass" of tertiary holes was being made after three grouted holes intervened between successive tertiary holes along the line.

A-03. Location. The left abutment grout curtain is located between Stations 143+00 and 151+00 on the dam axis. The right abutment grout curtain is located along a line that originates at a point on Station 82+20 of the dam axis and extends, in succession, to the following five points:

Dam Axis Station	Range
84+60	Centerline of dam
85+62.23	0+63.0' Upstream
87+02.04	0+62.85' Upstream
88+04.42	Centerline of dam
88+64.42	Centerline of dam

A-04. Bedrock stratigraphy. --Bedrock in both abutments consists of a sequence of limestone and shale beds, all of Permian age, and in decending order are as follows:

a. Towanda limestone member; --The Towanda is a hard, dense, thin-bedded limestone about 15 feet thick. Solutioning and softening due to weathering has opened the bedding planes and joints in the limestone and appreciably reduced the strength of several thin interbedded shale layers.

b. Holmesville shale member. --The Holmesville is 13 to 18 feet thick, soft, laminated, and interbedded with thin discontinuous limestones toward the base. A solution zone is generally present within five feet of the base.

c. Fort Riley limestone member. --The Fort Riley member is about 38 feet thick at the damsite and consists of thin-bedded to massive, argillaceous and shaly limestone. It has been subdivided on the basis of lithology into five zones in descending order as follows:

(1) Zone A. --Zone A, the upper zone, consists of approximately 13 feet, of thin-bedded, moderately hard, dense, argillaceous and shaly limestone.

(2) Zone B. --Zone B is medium-bedded, moderately hard, argillaceous, light gray limestone about 6 feet thick. It contains scattered vugs or solution pits.

(3) Zone C. --Zone C is limestone about 9 feet thick, thin-bedded, moderately hard, dense, argillaceous, and light to dark gray.

(4) Zone D. --Zone D is a hard, dense, massively bedded limestone. It is characteristically solution pitted. Zone D is approximately 8 feet thick and forms a conspicuous outcrop called the "rimrock" along the valley walls at the damsite.

(5) Zone E. --Zone E is the basal member of the Fort Riley and is a massive limestone ranging in thickness from less than a foot to 4 feet. It is hard, fine-grained and dark gray.

d. Oketo shale member. --The Oketo member is moderately hard, calcareous, massive, dark gray shale which ranges in thickness from 4.5 to 6.8 feet. It is the most competent shale at the damsite and shows unusually high resistance to weathering and slaking.

e. Florence limestone member. --The Florence member consists generally of about 36 feet of hard, cherty, thin to medium bedded limestone. It has been subdivided on the basis of lithology into four zones in descending order as follows:

(1) Zone A. --Zone A is a hard limestone, thin to medium bedded, dense, very cherty (nodular), gray and tan colored. It is about 15 feet thick.

(2) Zone B. --Zone B, about 5.5 feet thick, is a massive, hard, dense, tan limestone containing numerous small vugs or solution pits.

(3) Zone C. --Zone C is about 11 feet thick, is a thin-bedded, hard, dense, cherty limestone of tan and gray color.

(4) Zone D. --Zone D is about 4.5 feet thick. It is limestone, thin to medium bedded, dense and gray. It becomes very shaly at its base.

f. Blue Springs shale member. --The Blue Springs shale is about 33 feet thick and has been subdivided on the basis of lithology into two zones. The upper zone (A) is about 20 feet thick and consists of soft, calcareous, red and green shale. It contains a limestone bed about 1 foot thick near its base. The lower zone (B) is about 13 feet thick and consists of a fissile, moderately hard, calcareous, dark gray shale. Zone B contains an occasional nodule and a few thin seams of gypsum. The gypsum amounts are so minor that solutioning of them should not materially affect foundations.

A-05. Sequence of operations, right abutment. --Drilling and grouting began on 1 February 1963 and was completed on 3 July 1963 by means of a Failing 1500 "S" type rotary drill employing air as the drilling fluid. An NX hole was drilled to full depth by means of fishtail and rock bit. The hole was then grouted by the "stop" method of grouting, which consists in drilling a hole to full depth, then pressure testing and grouting the lowest zone present; then, with successively shallower settings of an inflatable packer, pressure testing and grouting each groutable horizon of the hole until the uppermost groutable horizon has been grouted. The grouted hole is then backfilled, this being done by means of a tremie pipe unless the grout present in the hole is at a level above the 20-foot depth, in which case the backfill grout is merely squirted into the top of the hole by means of the grout delivery line.

Four other holes, spaced at 40-foot intervals, were then successively drilled and grouted in the above-indicated manner, with each hole being completed (pressure-tested, grouted and backfilled) prior to the start of any nearby hole. The five completed holes were then tentatively designated as "primary," pending the performance of holes to be drilled midway between them.

A secondary hole and two tertiary holes adjacent to it were completed next, so as to provide as soon as possible a grouted section of line that could be tested for tightness by means of a test hole angled at 20 degrees. Accordingly, the section of line between Stations 83+80 and 84+20, having five vertical grout holes at 10-foot intervals, was ready for testing.

The five holes had taken a total of 418 sacks of cement (grout), but it was not known whether there existed sufficient communication between open horizontal bedding planes and vertical joints so as to allow free movement of grout to vertical joints not encountered by the drill.

An angle hole of NX size, inclined riverward at an angle of 20° with the vertical, was drilled to full depth (127.0 feet) with a Longyear Model 44 rotary drill. This hole, experimental hole 83+60, was then pressure tested and grouted by the "stop" method of grouting. In four successive settings of the packer, it was proved that the lower four of the then-supposed five groutable zones encountered in the hole were tight. The lower half of the Florence limestone, the upper half of the Florence limestone, and the "D" and "B" zones of the Fort Riley limestone proved to be tight. The "A" zone of the Fort Riley limestone could not be satisfactorily pressure tested. Since the base of the Towanda limestone is 10 feet above spillway crest elevation, grouting was not considered necessary. After testing the first 20-degree angle hole, it was decided to bring more of the grout line to a 10-foot-spacing as soon as possible, and, with additional 20-degree angle holes, verify what the first angle hole had indicated: that vertically drilled holes might prove to be a satisfactory means of delivering the grout to the vertical joints. Accordingly, nine more holes were drilled and grouted, as above, and generally in the order dictated by the necessity for avoiding conflict with the access road Contractor.

Thus the next nine holes to be completed were drilled and grouted in what appears to be aimless order: tertiary, primary, tertiary, primary, etc. At this point in the operation, with 18 vertical holes drilled and grouted, enough of the grout line had been completed with 10-foot-spaced holes so as to provide a grouted section for additional testing by means of a second 20-degree angle hole. However, Contractor's operations in the area prevented drilling of the planned angle hole. Accordingly, the second angle hole was drilled elsewhere (at Station 83+68). This hole (angle hole 83+65) was drilled to depth 50 feet with air as the drilling fluid. It could not be drilled deeper by such means, and water was then used as the drilling fluid in advancing the hole to full depth, through the Florence limestone and into the Blue Springs shale.

The second angle hole gave results similar to those of the first angle hole, proving tight in all horizons below the "A" zone of the Fort Riley limestone, with that zone taking 38 g.p.m. of water in the pressure test and 13 sacks of cement (grout).

NOTE: In the light of experience gained in testing and grouting of the Holmesville shale since that time, it is considered likely that the 13 sacks of cement (grout) entered the Holmesville shale instead of the "A" zone of the Fort Riley limestone. During subsequent operations, much grout was injected into a stained solution-opened horizontal bedding plane that persists in the lower part of the Holmesville shale. This bedding plane, undoubtedly encountered by the 20-degree angle hole, could easily have been opened wider during the pressure test. The water pressure (35 p.s.i. on gage, plus head pressure) totaled 49 p.s.i.: too much to apply to the bedding plane, which lies at a vertical depth of 36-37 feet at this location on the grout line.

A third test hole 83+00), angled at 20-degrees, was then drilled to full depth at a location approximately 60 feet southward of the first two angle holes. It proved tight in all zones below the "A" zone of the Fort Riley limestone, which horizon took 4 sacks of cement (grout). At this point in the experimental grouting operation, it became reasonably certain that the right abutment grout curtain could be satisfactorily installed by means of vertical holes spaced at 10-foot intervals and grouted by the "stop" method. Two additional angle holes were drilled and tested.

Angle hole 83+05, drilled with air as the drilling fluid and tested progressively (by stage method) as the hole was advanced, took 24 g.p.m. of water and 14 sacks of cement (grout) in the Florence limestone. But this, the first angle-hole "take" in the Florence limestone, was attributed to the fact that this section of Florence had not been grouted on 10-foot centers, but on 20-foot centers. (Tertiary hole 83+50, which later halved the 20-foot space, had not yet been drilled.) Again, in this angle hole, there was a very considerable "take" (59 sacks cement) when the packer was set in the Holmesville shale. This "take," then supposed to have occurred in the "A" zone of the Fort Riley limestone, is now believed to have occurred in the solution-opened horizontal bedding plane that is present in the lower part of the Holmesville shale. A fifth angle hole (83+70), drilled with water as the drilling fluid, proved tight in all zones except the "D" zone of the Fort Riley limestone, where four sacks of cement (grout) were injected.

At this point in the operation, a review of the drilling and grouting data indicated that 10-foot spacing of grout holes would generally suffice to achieve installation of the grout curtain, and that vertical holes could be employed. All drilling and grouting operations that followed were performed in a more orderly manner. Primary holes, initially spaced at 80-foot intervals and finally at 40-foot intervals, were drilled to full depth and then grouted by the "stop" method. The interval between open ungrouted primary holes was always kept at 80 feet, which was adequate to prevent hole-to-hole communication of grout. When the drilling and grouting of the primary holes were completed, work was begun on the remaining secondary holes. Again, hole-to-hole communication of grout was carefully avoided by maintaining an 80-foot interval between successive open (ungrouted) secondary holes. Upon completion of the secondary holes, the tertiary holes were drilled and grouted in similar manner, with the 80-foot interval between open tertiary holes usually maintained.

Completion of the 34 tertiary holes resulted in a completed grout hole at each 10-foot interval along the entire length (680') of the line. With the line thus brought to 10-foot spacing, it was thought proper to test the tightness of the grout curtain by means of angle holes drilled into various parts of the curtain that were suspected of being open. In general, those parts of the curtain that had taken little or no grout were suspected, since it was assumed that failure of a zone to accept grout had been caused by failure of the vertical grout holes to communicate with vertical joints.

Accordingly, six additional 20° angle holes were drilled to full depth at Stations 87+82, 87+34, 86+51, 85+50, 84+54 and 82+65.

Combined grout "takes" of the final six 20-degree angle holes was as follows:

Zone	Sacks Cement (Grout) (Total for six holes)
Towanda limestone	88
Holmesville shale	35
A Zone (Ft. Riley)	27
B Zone (Ft. Riley)	4
D Zone (Ft. Riley)	0
Florence limestone	0

As a final precautionary effort, eight more vertical quaternary holes, spaced at 10-foot intervals, were added in the most landward 75-foot section of the grout line, (Station 88+25 to Station 89+00). Only 16 of a possible total of 68 quaternary holes were drilled. Thus the right abutment grout curtain is grouted with vertical 5-foot-spaced holes along 160 feet (24%) of it 680-foot length. The remaining 520 feet of the grout curtain is grouted with vertical holes spaced at 10-foot intervals. Only four of the 16 quaternary holes penetrated the Florence limestone. Thus only 40 feet (6%) of the lateral extent of the Florence limestone is grouted with vertical holes spaced at five-foot intervals, while 640 feet of it (94%) is grouted with vertical holes spaced at 10-foot intervals.

A-06. Sequence of operations, left abutment. --Drilling and grouting on the left abutment began on 5 July 1962 and was completed 15 November 1962. Towanda limestone in the immediate area was overlain by a blanket of sand approximately 13 feet thick and casing was required in drilling some of the grout holes. The first phase of the work consisted in drilling and grouting eleven primary holes spaced at 80-foot intervals along the entire 800-foot length of the grout line (Station 151+00 to Station 143+00 on the dam axis). The second phase of the work consisted in drilling and grouting 10 more primary holes, spaced at 80-foot intervals, with each successive hole being located midway between successive pairs of the initial eleven primary holes. Of the 21 primary holes drilled, complete loss of drilling fluid (water)

occurred in fifteen. With the 21 primary holes completed at 40-foot intervals along the entire length of the grout line, a comparison of the cement (grout) consumption that had occurred in the two groups of primary holes was made. The first group (eleven holes) took a total of 1,931 sacks of cement (grout), for an average of 176 sacks per hole. Florence limestone took an average of 70.4 sacks per hole. The second group (ten primary holes), which were regarded as "secondary" primary holes, took a total of 1,915 sacks of cement (grout), for an average of 192 sacks per hole, and the Florence limestone took an average of 55 sacks per hole. The conclusions arrived at were as follows:

a. Grout injected into the first group of primary holes had not traveled a distance of 80 feet horizontally in any of the grouted zones above the Florence limestone.

b. Grout injected into the Florence limestone could possibly have traveled more than 80 feet horizontally.

c. The secondary, tertiary, and other grout holes yet to be drilled could safely be left open without the risk of their being accidentally undergrouted by premature introduction of grout originating from grout-pumping operations conducted on holes 80 feet away. As the Florence limestone had taken thick grout rather well, it was believed that the grout already placed in that member would prevent hole-to-hole travel of grout in secondary holes.

Drilling and grouting of the secondary holes with the 80-foot interval between, was maintained as successive "passes" of the drill and grout machine were made along the grout line. However, the drilling and grouting sequence was interrupted after only 13 of the 20 secondary holes had been completed, when the Contractor expressed a desire to begin cut-off-trench blasting operations along the riverward 100 feet of the grout line. It then became necessary to complete the landward 100 feet of grout line early by drilling and grouting the following six tertiary holes ahead of schedule: Stations 143+50, 143+10, 143+90, 143+70 and 143+30.

After the landward 100 feet of grout line was completed on 10-foot centers, the remaining seven secondary holes were drilled and grouted, which made a grouted hole at each 20-foot interval. A complete loss of drill water occurred during drilling of two of the secondary holes. Tertiary drilling began with 40-foot spacing in order to shorten "moves" of the drill and grouting machine but after five holes were complete inter-hole communication occurred. Wash water from tertiary hole 150+90 traveled through the sand overlying the Towanda limestone, or possibly through the Towanda joints, and entered cased tertiary hole 150+50. The 80-foot spacing was resumed.

During the last (third) teritary-hole "pass" along the grout line; with three completely grouted and backfilled holes between the successive pairs of remaining tertiary holes, the 80-foot interval was discontinued in favor of the 40-foot interval. On completion of all (40) tertiary holes, the grout line included a completed (grouted) hole at each 10-foot interval along the full length of the line.

A stage-drilled angle test hole, (hole 149+68), was then drilled in order to test "tightness" of the grout curtain. This hole was inclined riverward twenty degrees. It took 9 sacks of cement (grout) in the "A" zone and 5-3/4 sacks in the "D" zone of the Fort Riley limestone, with all other groutable zones proving tight. As the injected grout was of high water-cement ratio (3:1, 2:1 and 1.5:1) and as the time required for injection of the grout was in both cases rather prolonged, (9-sack injection requiring 68 minutes, 5-3/4-sack injection requiring 60 minutes), it was concluded that the two "takes" of grout were not great enough to warrant the drilling quaternary holes in that area of the grout curtain. The 10-foot spacing of holes appeared to be sufficient.

The overburden overlying the top of bedrock was troublesome in that it very often was not firm enough to provide sufficient purchase for the setting of grouting packers. As a result, in many parts of the grout curtain, the uppermost groutable horizon had been undertreated. A series of shallow quaternary holes was drilled, along with additional 20-degrees-angle test holes. The results of pressure-testing and grouting of the five 20-degree-angle test holes are as follows:

Zone	Sacks Cement (Grout) (Total for Five Holes)
Towanda limestone	2
Holmesville shale	0
"A" Zone (Fort Riley)	27-1/2
"B" Zone (Fort Riley)	0
"D" Zone (Fort Riley)	18-1/4
Florence limestone	0

After completion of 34 quaternary holes, two shallow-depth quinary holes (145+42.5; 145+62.5) were drilled in two areas of the grout curtain suspected of being open. The two holes took a total of four sacks of cement (grout). Only 34 of a possible 80 quaternary holes were drilled. Thus the left abutment grout curtain is grouted with vertical 5-foot spaced holes along only 340 feet (43%) of its 800-foot length. The remaining 460 feet of the grout curtain is grouted with holes spaced at 10-foot intervals. Only 14 of the 34 quaternary holes penetrated the "D" zone of the Fort Riley limestone, and only four of them penetrated the Florence limestone. Thus only 130 feet (16%) of the lateral extent of the "D" zone of the Fort Riley limestone was grouted with vertical holes spaced at 5-foot intervals, and only a 5% of the Florence limestone was grouted on such close spacing of holes.

A-07. Results and Conclusions. Results of the experimental drilling and grouting program are summarized in tables 1 thru 18, Pages IV-A-17 thru IV-A-33. The following conclusions were made:

(1) Inclined (angle) drill holes are not necessary for installation of a grout curtain but because they offer a better chance for inception of vertical joints, angle holes are superior to vertical holes as a means of grouting a formation containing vertical joints.

(2) The use of air as a drilling fluid proved workable but was less effective than the use of water. Air-drilling was given a trial and then abandoned in favor of the water drilling. As employed in drilling 14 of the 96 NX-size holes of the right abutment grout curtain, the air-drilling rate averaged only half as fast as water-drilling. Water-drilling proved superior in several instances when drill rods and drill bit suddenly became tightly widged in the hole. Just as a drill that employs water as the drilling fluid can lose the water in an open joint, so a drill that employs air as the drilling fluid can lose air to such extent that very little air (far too little to remove cuttings from the hole) returns to the ground surface. When such action occurs in an air-drilled hole, not all the cuttings can escape into the open joint that is accepting the air, especially if the drill, as it descends, next enters a soft or a fairly moist shale. As moist or wet shale does not readily reduce to a manageably buoyant powder or to small non-adhering particles of rock, the result is often an accumulation of moist shale particles (probably at a level slightly above the indicated open joint). As drilling is continued, the particles rapidly collect into an adhering mass that prevents upward travel of the air and soon causes the drill rods to become tightly bound. Injections of water or detergent-treated water through the air line prevented the above described action to some extent but not to a sufficient extent.

(3) The bit found to be most effective for drilling of the very cherty Florence limestone proved to be the K-2 type of roller rock bit. The next best bit used was the K-1 type of roller rock bit. Both types are manufactured by Oil Tool Manufacturing Co., Inc., of Tonkawa, Oklahoma, and the writer recommends the K-2 type for NX boring of hard material. Rebuilt bits of either type (K-1 or K-2) proved generally unsatisfactory in that their bearings often failed to survive one drilling of the Florence limestone. Although several attempts were made to drill two full-depth holes with the same K-2 type of bit, only one of the attempts was successful, and this proved to be too time-consuming. It was far more economical to use a new roller rock bit in each hole to be drilled through the Florence limestone, and this was the procedure that became standard. Thus the number of roller rock bits consumed in the drilling is approximately equal to the number of holes drilled through the Florence limestone. Material other than the Florence limestone was readily and rapidly drilled with even fishtail bits and presented no problem.

TABLES

TABLES

Table 1.-- Footage Figures (Right Abutment)

Type of Hole	Holes Drilled	Feet Drilled
Primary	18	2,180
Secondary	17	2,051
Tertiary	34	4,094
Quaternary	16	1,374
Quinary	--	--
Angle	11	1,369
Totals	96	11,068*

*Includes overburden

Table 2.-- Summary of Drilling Footage (Right Abutment)

Feet Drilled	Type of Material Drilled
676	Overburden
7,876	Six horizons grouted (bedrock)
2,516	Four horizons not grouted (bedrock)
11,068	Total of all drilling

Table 3.-- Formation Footage (Right Abutment)

Formation	Feet Drilled
Overburden	676
Towanda limestone	1,140
Holmesville shale	1,453
Zone "A" (Fort Riley)	1,119
Zone "B" (Fort Riley)	485
Zone "D" (Fort Riley)	954
Florence limestone	2,725
Total	8,552*

*Excludes horizons not grouted: "C" Zone and "E" Zone of Fort Riley limestone, the Oketo shale and the Blue Springs shale. These horizons required 2,516 feet of drilling.

Table 4.-- Drilling and Grouting of Towanda Limestone. Right Abutment

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	18	0	0	211	--	--	--*
Secondary	17	0	0	200	--	--	--*
Tertiary	34	12	12	398	244	20.3	0.61
Quaternary	16	10	8	203	74	9.3	0.36
Quinary	--	--	--	--	--	--	--
Angle	11	6	6	128	107	17.8*	0.84*

*No attempt was made to test or grout the Towanda limestone until work had progressed into the tertiary hole phase. By that time, however, all primary and secondary holes, and approximately half the 34 tertiary holes of the grout curtain had been completed. Thus the Towanda limestone of the right abutment remains ungrouted along nearly the full extent of the grout line, except between grout line Stations 88+20 and 89+00.

Table 5.-- Drilling and Grouting of Holmesville Shale.
Right Abutment

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	18	17	17*	271	327	19.2	1.20
Secondary	17	17	15*	259	140	9.3	0.54
Tertiary	34	34	31*	516	289	9.3	0.56
Quaternary	16	16	14*	221	38	2.7	0.17
Quinary	--	--	--	--	--	--	--
Angle	11	11	10*	186	90	9.0	0.47*

*It was often impossible, when testing the "A" zone of the Fort Riley Limestone, to obtain a tight packer setting at the base of the Holmesville shale, because the shale there is generally too soft and too yielding to allow the setting of a packer. Packers set at the base of the Holmesville shale usually "blew out," and so the place was avoided. Thus the packer was ordinarily set at a higher level, with the result that two groutable zones -- the horizontal bedding plane of the Holmesville shale and the "A" zone of the Fort Riley limestone.

Table 6.-- Drilling and Grouting of "A" Zone (Fort Riley Ls.) Right Abutment

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	18	18	18*	209	313	17.4	1.50
Secondary	17	16	16*	195	183	11.4	0.94
Tertiary	34	32	32*	391	264	8.2	0.68
Quaternary	16	16	16*	188	91	5.7	0.48
Quinary	--	--	--	--	--	--	--
Angle	11	11	10*	136	69	6.9	0.51*

*See note table 5

Table 7.-- Drilling and Grouting of "B" Zone (Fort Riley Ls), Right Abutment

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	18	18	17	90	428	25.2	4.76
Secondary	17	17	17	85	80	4.7	0.94
Tertiary	34	34	32	170	153	4.8	0.90
Quaternary	16	16	14	80	4	0.29	0.05
Quinary	--	--	--	--	--	--	--
Angle	11	11	11	60	5	0.45	0.08

Table 8.-- Drilling and Grouting of "D" Zone (Fort Riley Ls.)
Right Abutment

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	18	18	18*	180	1,419	78.8	7.9
Secondary	17	17	17	170	225	13.2	1.3
Tertiary	34	34	34	340	25	0.74	0.07
Quaternary	15	15	14	150	6	0.43	0.04
Quinary	--	--	--	--	--	--	--
Angle	11	11	11	114	5.5	0.50	0.05

*Only 17 were successfully pressure tested. The 18th holes is presumed to have taken 32 sacks of cement.

Table 9.-- Drilling and Grouting of Florence Limestone, Right Abutment

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	18	18	18	580	1,338	74.3	2.3
Secondary	17	16*	16	546	331	20.7	0.6
Tertiary	34	33*	33	1,094	407	12.3	0.37
Quaternary	4	4	4	126	18	4.5	0.14
Quinary	--	--	--	--	--	--	--
Angle	11	11	11	379	14	1.3**	0.04

*Holes caved. Could not be tested.
**Ten of the eleven holes were tight. The eleventh (angle hole 83+05) took the 14 sacks of cement (grout), but the area was devoid of any tertiary hole. The prevailing interval between grouted holes was 20 feet at the time.

Table 10

FOOTAGE FIGURES
(Left Abutment)

Type of Hole	Holes Drilled	Feet Drilled
Primary	21	2,255
Secondary	20	2,160
Tertiary	40	4,278
Quaternary	34	1,366
Quinary	2	47
Angle	5	602
Total	122	10,708*

*Includes Overburden.

Table 11

SUMMARY OF DRILLING FOOTAGE
(Left Abutment)

Feet Drilled	Type of Material Drilled
874	Overburden
6,942	Six Horizons Grouted
2,892	Four Horizons Not Grouted*
10,708	Total of all drilling.

*These horizons did not accept grout:

"C" Zone (Ft. Riley)

"E" Zone (Ft. Riley)

Oketo shale

Blue Springs shale

Table 12

FORMATION FOOTAGE
(Left Abutment)

Formation	Feet Drilled
Overburden	874
Towanda Limestone	287
Holmesville Shale	1,042
Zone "A" (Ft. Riley)	1,120
Zone "B" (Ft. Riley)	545
Zone "D" (Ft. Riley)	954
Florence Limestone	2,994
	7,816*

*Excludes horizons not grouted: "C" Zone and "E" Zone of Ft. Riley limestone, the Oketo shale and the Blue Springs shale. These horizons required 2,892 feet of drilling.

Table 13

DRILLING AND GROUTING OF TOWANDA LIMESTONE, LEFT ABUTMENT

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	10	9	9	60	489	54.3	8.2
Secondary	10	9	9	60	160	17.8	2.7
Tertiary	20	18	13	113	138	10.6	1.2
Quaternary	6	5	5	34	13	2.6	0.4
Quinary	-	-	-	-	-	-	-
Angle	3	3	3	20	2	0.7	0.1
Total --					802		

Table 14

DRILLING AND GROUTING OF HOLMESVILLE SHALE, LEFT ABUTMENT

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	14	13	13	207	291	22.4	1.4
Secondary	14	14	14	195	50	3.7	0.25
Tertiary	28	26	23	395	85	3.7	0.22
Quaternary	17	16	16	173	28	1.7	0.16
Quinary	2	2	2	5	0	0.0	0.0
Angle	4	4	4	67	0	0.0	0.0
Total --					454		

Table 15

DRILLING AND GROUTING OF "A" ZONE (FT. RILEY LS.), LEFT ABUTMENT

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	19	19	18	196	979	54.4	5.0
Secondary	19	18	17	183	797	46.9	4.3
Tertiary	38	34	34	384	256	7.5	0.67
Quaternary	34	31	31	279	102	3.3	0.36
Quinary	2	2	2	26	4	2.0	0.15
Angle	5	5	4	52	27-1/2	6.9	0.53
Total --					2,165		

Table 16

DRILLING AND GROUTING OF "B" ZONE (FT. RILEY LS.), LEFT ABUTMENT

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	20	20	18	101	215	12.0	2.13
Secondary	20	19	19	98	76	4.0	0.77
Tertiary	40	38	37	196	214	5.7*	1.09*
Quaternary	24	24	24	118	41	1.7	0.35
Quinary	1	1	1	5	0	0.0	0.0
Angle	5	5	5	27	0	0.0	0.0
Total --					546		

*Note: The high figure is ascribable to "jacking" believed to have occurred during grouting of holes 143+70 (94 sacks) and 143+90 (90 sacks).

Table 17

DRILLING AND GROUTING OF "D" ZONE (FT. RILEY LS.), LEFT ABUTMENT

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	21	21	21	198	543	25.9	2.23
Secondary	20	20	20	188	341	17.0	1.81
Tertiary	40	40	40	379	237	5.9	0.62
Quaternary	14	14	14	139	0	0.0	0.0
Quinary	-	-	-	-	-	-	-
Angle	5	5	5	50	18-1/4	3.6	0.36
Total --					1,139		

Table 18

DRILLING AND GROUTING OF FLORENCE LIMESTONE, LEFT ABUTMENT

Type	Holes Drilled Through Formation	Holes Pressure Tested	Holes Successfully Pressure Tested	Total Footage (All Holes)	Sacks Cement Injected	Sacks Cement Per Hole (In Holes Successfully Tested	Sacks Cement Per Lineal Foot (All Holes)
Primary	21	21	21	698	1,329	63.3	1.90*
Secondary	20	20	20	663	400	20.0	0.60
Tertiary	40	40	40	1,319	54	1.4	0.04
Quaternary	4	4	4	137	0	0.0	0.0
Quinary	-	-	-	-	-	-	-
Angle	5	5	5	177	0	0.0	0.0
Total --					1,783		

*"Per lineal foot" has little application here. It is practically certain that all grout delivered to the Florence Limestone entered the solution channel located at the "B" Zone - "C" Zone contact.